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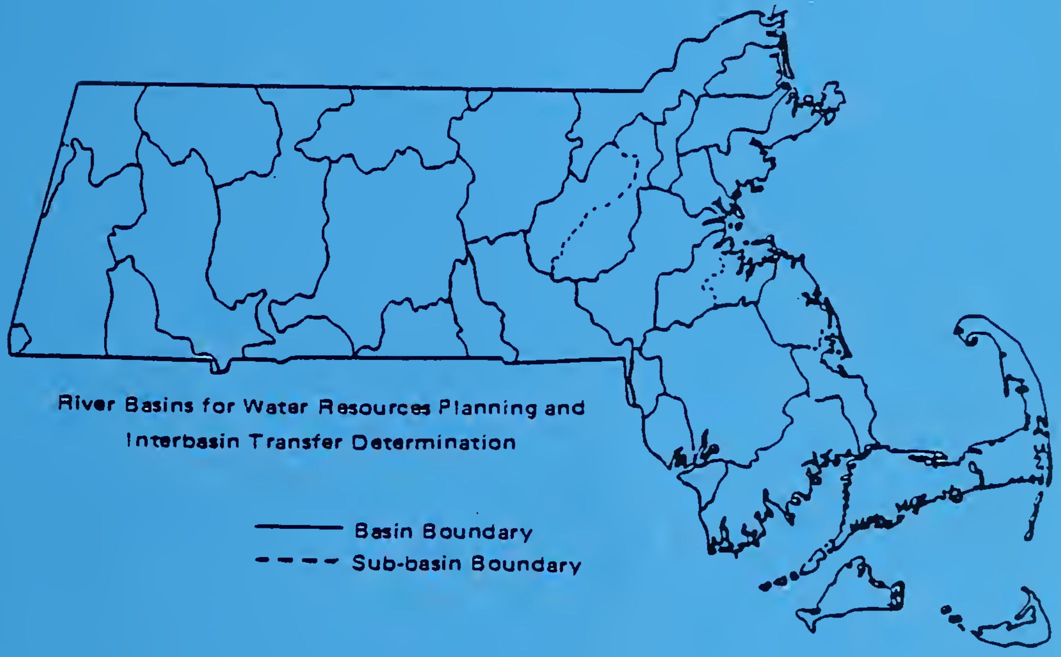
# Blackstone River Basin

## Inventory and Analysis of Current and Projected Water Use



River Basins for Water Resources Planning and Interbasin Transfer Determination

Massachusetts Department of Environmental Management
Division of Water Resources
May 1985

# BLACKSTONE RIVER BASIN

## Inventory and Analysis of
## Current and Projected Water Use

Department of Environmental Management
Division of Water Resources

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RIVER BASIN
PLANNING PROGRAM

Report No. 6

# PREFACE

The Division of Water Resources in the Department of Environmental Management is responsible for long-range planning in Massachusetts. The central element of this planning effort is the preparation of a water resources plan for each of the twenty-seven river basins of the Commonwealth.

This report is the first in a series of reports that will summarize an inventory and analysis of current and projected water use in the state's river basins. The reports provide baseline data needed to develop river basin plans and will assist professionals in the day-to-day planning and management of our water resources. The information in the report on current public water supply sources and uses, demography, population forecasts, and estimated future water needs is intended for broad river basin planning purposes. Additional data and analysis is needed for more exact planning efforts such as that needed for the development of municipal water supply sources. The information comes from different sources and the reader should review carefully the paragraphs explaining the sources of data to understand the origin, date and other important qualifiers of the data and analyses.

The river basin planning program is part of the Division's commitment to meet one of the goals of the Department of Environmental Management - "to demonstrate the interdependence between economic and environmental policies and actions in ensuring a high quality of life for the citizens of the Commonwealth" - and to attain the state's overall water supply goal of ensuring that water is available in sufficient quantity and quality to meet Massachusetts' current and future consumptive and non-consumptive water needs.

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# I. Introduction

## Purpose

The Water Resources Planning Regulations (313 CMR 2.00) adopted by the Massachusetts Water Resources Commission established a framework for the development of comprehensive water resources plans for the twenty-seven river basins of the Commonwealth and for development of a statewide water resources management plan.

The Department of Environmental Management's Division of Water Resources is implementing the planning process outlined in the regulations which provide that basin plans be based on local, regional and state assessments of water needs and resources and be in conformance with the Massachusetts Water Supply Policy Statement. The assessment of available water resources will be fulfilled by the Chapter 800 Basin Studies which are being prepared cooperatively with the U.S. Geological Survey to provide baseline data on river basins in the Commonwealth.

## Planning Process (See Figure 1)

The river basin planning process consists of four steps:

1. Inventory of the basin's water resources, demand and uses
2. Analyze data and identify current and projected water needs
3. Develop alternatives to meet needs
4. Prepare water resources management plan and obtain Water Resources Commission approval

In view of the enormity and complexity of the task, the water supply element of the basin plan is being prepared first. Such items as water storage, water quality and minimum streamflow requirements will be considered as they directly relate to water supply issues.

The Division of Water Resources is proceeding with the inventory and analysis steps of the planning process. The inventory includes the collection of existing data on the basin's developed surface and groundwater resources, current water demand and use, water supply sources, water quality, minimum streamflow rates and short-term and long-term demographic profile of the communities in the basin.

The analysis step includes analyzing the inventory data and preparing short-term and long-term water demand projections. When the Chapter 800 basin studies have been completed, basin water budgets can be prepared to estimate the volume of water available for water supply under average precipitation and drought conditions, allowing for the maintenance of instream uses and environmental quality. The basin water budgets also can provide the basis for estimating a basin's ability to meet projected demands on its available water resources.

## Inventory and Analysis of Current and Projected Water Use

The purpose of this report is to summarize the significant water demand and use data for the Blackstone Basin communities. The report includes 1980 water use and demand data for public water supply systems, information on the sources of the public water supply systems, 1980 population figures,1990-2020 population forecasts and 1990-2020 projected water demands.

The data was obtained by the Division of Water Resources from the superintendents of twenty-eight public water supply systems and from the Division of Water Supply of the Massachusetts Department of Environmental Quality Engineering. Considerable time was spent checking the data so that it would be as accurate as possible. This process included the answering of two questionnaires by the local water supply agencies. The second questionnaire was "personalized" for each system. It contained water resources data which had been compiled for that system from the first questionnaire and other sources. Each superintendent was requested to review, update and verify the accuracy of the water resources data. Questions and discrepancies were reconciled through discussions with responsible officials.

The population forecasts were obtained from the regional planning agencies and the Worcester Department of Planning and Economic Development. These forecasts are based on the 1980 Federal Census.

A base year of 1980 was selected because a Federal Census was conducted in that year and water demand figures for that year reflect water use during a somewhat below average precipitation year.

The 1980-2020 water demand projections utilized the methodology as outlined in appendix 3. This methodology is based on assumptions of what will be occurring in the basin in terms of population and water use during the next forty years. The projected water demand figures are for general basin planning purposes and are sound provided that the basic assumptions remain valid.

Preliminary estimates of residential, commercial/institutional, industrial and agricultural self-supplied water use were compiled by the Division of Water Resources staff utilizing the methodologies described in appendix 4 of this report. The figures represent an estimate of the volume of self-supplied water use without the benefit of a site specific water user inventory and should be regarded as the minimum volume of water used by self-supplied users.

## Use of Report

Readers of this report should keep in mind that the data contained herein is for broad basin planning only. Caution is recommended when using these data for more detailed analysis.

## MASSACHUSETTS WATER RESOURCES COMMISSION
## DIVISION of WATER RESOURCES
## RIVER BASIN PLANNING PROGRAM

FIGURE 1

### *313 RIVER BASIN PLANNING PROCESS*

| I. INVENTORY THE BASIN'S WATER RESOURCES, DEMANDS & USES | II. ANALYZE DATA AND IDENTIFY PROJECTED WATER NEEDS | III. DEVELOP ALTERNATIVES | IV. PREPARE WATER RESOURCES MANAGEMENT PLAN | V. ADOPT PLAN |
|---|---|---|---|---|
| Inventory the following data:<br>(a) Demographic profile of the river basin<br>(b) Water demand and use (public & self-supplied users).<br>(c) Existing & projected water supply sources<br>(d) Profile of the available basin water resources<br>(e) Water resource management structure & organization<br>(f) Profile of the quality of the basin's water resources<br>(g) Effectiveness of structural & non-structural means of flood damage control & low flow augmentation<br>(h) Water requirements for minimum flow (recreation, fish & wildlife) | (a) Analyze 1990-2020 projected population & economic growth<br>(b) Prepare 1990-2020 projected water needs<br>(c) Identify local, regional & other state agency assessments of water needs and resources (e.g. previous reports, local plans)<br>(d) Analyze the relationship between available water resources and projected needs by preparing a basin water budget | (a) Develop alternatives to meet projected basin water needs<br>(b) Analyze and compare the relevant economic, environmental and institutional impacts of the alternatives and their abilities to meet future needs | (a) Select alternative(s)<br>(b) Prepare draft plan that:<br>1. is based on local, regional and state assessments of water needs & resources;<br>2. is in conformance with the Mass. Water Supply Policy Statement;<br>3. is developed from data aggregated by river basin;<br>4. describes measures proposed for full development & protection of local water sources;<br>5. describes measures proposed for the protection of the basin's water resources; and<br>6. is consistent with other water-related state and federal plans<br>(c) Review and comment on draft plan by local, regional and state agencies<br>(d) Prepare final plan based on review comments | (a) WRC reviews draft & final plan and can adopt all or elements of the plan<br>(b) Adopted plan or elements serve as a policy guide and a basis for decision-making |

●————CONTINUOUS INTERACTION WITH LOCAL, REGIONAL AND STATE AGENCIES————●

Process as outlined in 313 CMR 2.00: Water Resources Management Regulations

## II. Summary

- The Blackstone River Basin, located in south central Massachusetts with its headwaters in the towns adjoining Worcester, drains southeasterly through Rhode Island to Narragansett Bay.

- The Blackstone Basin includes eighteen communities with land area in the basin. Seventeen of these communities use the Blackstone Basin as a source for all or some of their public water supply.

- The 1980 water demand of the public water supply systems in the Blackstone Basin was approximately 39 million gallons per day (mgd).

- Blackstone Basin communities are served totally, or in part, by twenty-eight separate public water supply systems. Neither Millville, nor Mendon, has a public water supply system, although a section of Mendon is served by the Milford Water Company.

- The Worcester water supply system, serving 161,800 people, is the largest in the Blackstone Basin and has an average day demand of 26 mgd or 66 percent of the total public water supply use in 1980.

- Over one-half of the Blackstone Basin's public water supply comes from sources located outside of the basin. In 1980, 17 mgd or 77 percent of the 22 mgd coming from out-of-basin sources were used by the Worcester water supply system.

- Surface sources supplied 61 percent of the water used by public water supply systems in the Blackstone Basin. Surface supplied water was used in four of the basin communities. Worcester used 99 percent of the water coming from surface sources.

- All eighteen communities obtain part of their public water supply from groundwater sources, while fourteen obtain all of their supply from groundwater.

- In 1980, of the 320,042 people living in the eighteen Blackstone Basin communities, 282,643 or 89 percent obtained their water supply from public water supply systems. Worcester, the principal population center of 161,799, accounted for close to 50 percent of the basin's population.

- By 1990, the basin's population is projected to decline by less than 1 percent to 319,000, and then increase 3 percent per decade to 350,000 in 2020.

- Worcester's population is projected to decline to about 152,000 in 1990 and then slowly increase to the 1980 level of approximately 162,000 by the year 2020.

- Basin communities projected to have the largest percentage population increase between 1980 and 2020 are: Bellingham (54 percent), Sutton (32 percent), Mendon (29 percent), and Upton (25 percent).

- Between 1980 and 2020, the average day water supply demand of the basin communities is projected to increase approximately 33 percent from 39 mgd to 52 mgd. This represents an average increase of 0.8 percent a year over the 40 year period. (See Figure 2)

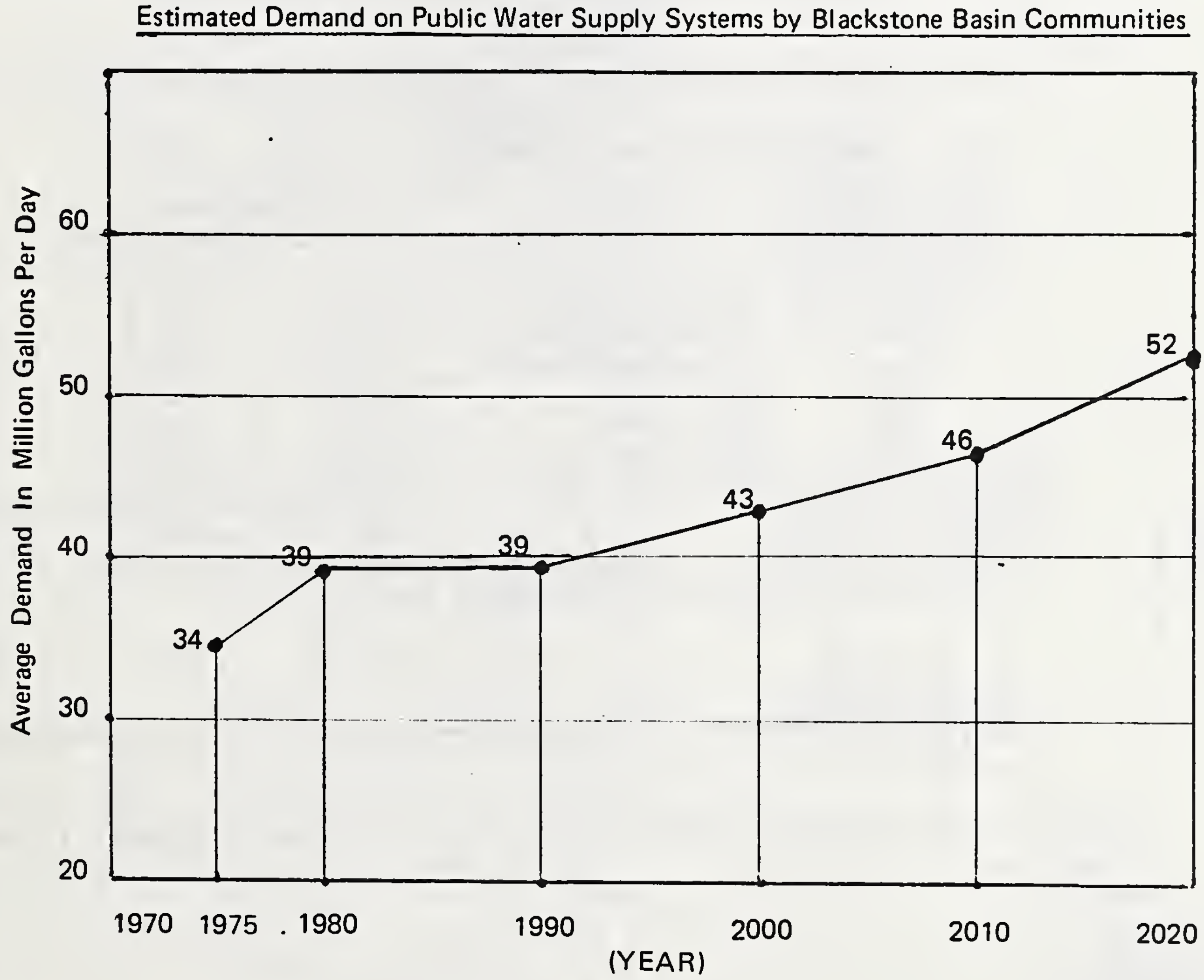
- The reasons for the 0.8 percent increase are expanded service areas, an increase in population in certain basin communities, a gradual overall increase in per capita water use and commercial and industrial water use after 1990.

- Between 1980 and 1990, Worcester is projected to have a decrease in water use from 26 to 24 mgd. A gradual increase to 30 mgd is expected by 2020.

- The communities projected to have the largest volume increase in water use between 1980 and 2020 are: Worcester (5mgd), Shrewsbury (1 mgd), North Attleboro (1 mgd), Bellingham (0.9 mgd) and Auburn (0.8 mgd).

## FIGURE 2

### Estimated Demand-Public Water Supply Systems



## III. Blackstone River Basin Description

A. General - The Blackstone River Basin is located in south central Massachusetts. The basin is bounded on the east by the Charles River Basin and the Ten Mile River Basin; on the north by the Nashua River Basin and the Concord River Basin; and on the west by the French River Basin. Its headwaters arise in towns adjacent to the City of Worcester and drain southeasterly through Rhode Island to Narragansett Bay.

The total area of the basin is 493 square miles; it is 41 miles long and averages 12 miles in width. Approximately 335 square miles of the Blackstone Basin are in Massachusetts.

A map showing the Blackstone River Basin in relation to the other Massachusetts river basins is shown in Figure 3.

B. River and Tributaries - The Middle River and Mill Brook merge to form the Blackstone River in the southern part of Worcester. The Blackstone flows southeasterly for about 30 miles to the Massachusetts - Rhode Island border. The river drops from elevation 430 feet in Worcester to elevation 150 feet at the state line. This drop results in an average hydraulic gradient of 9 feet per mile. Principal sub-watersheds (tributaries) to the Blackstone River in Massachusetts are shown in the chart below.

Blackstone River Basin (Massachusetts Portion)

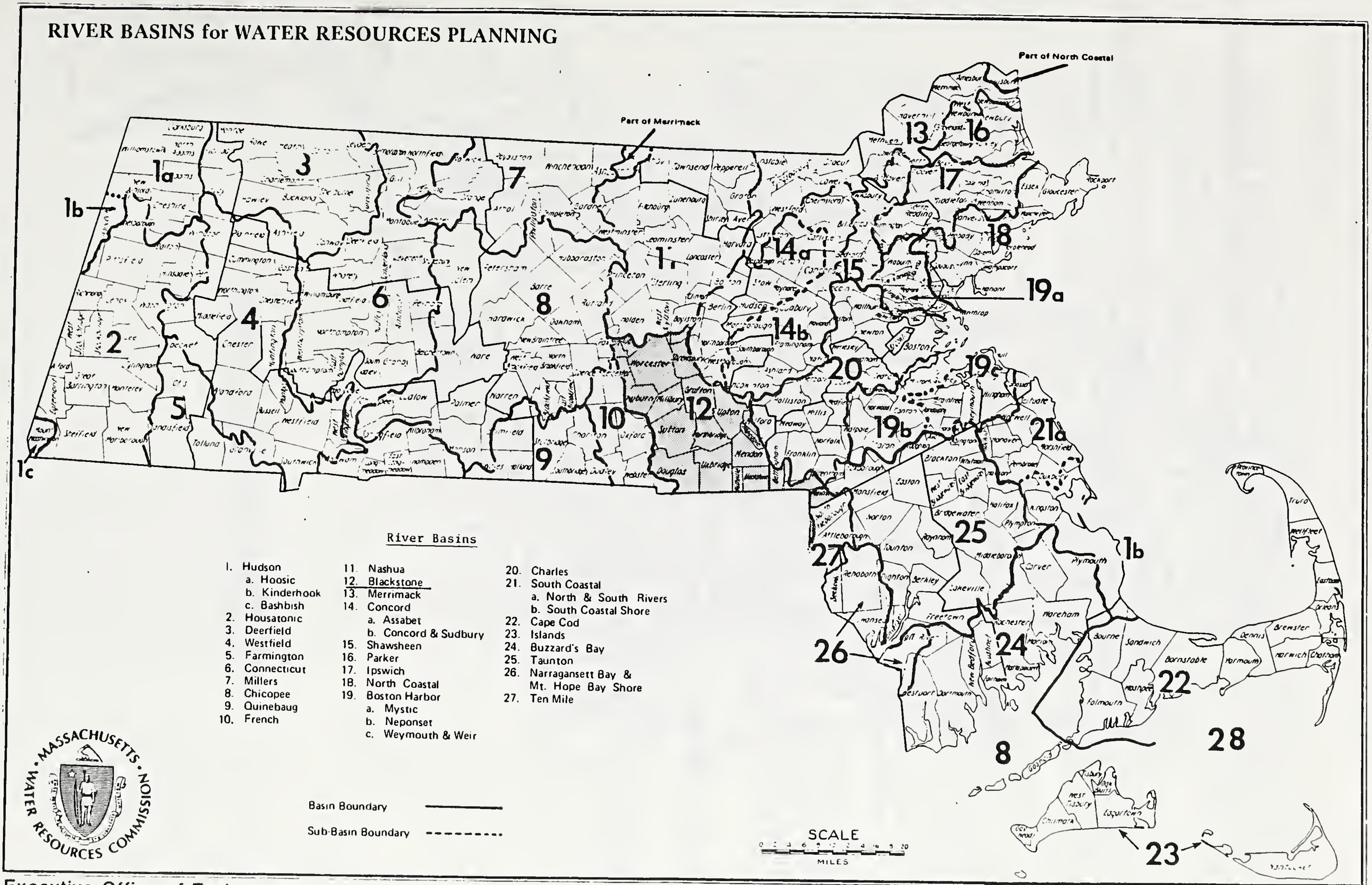
| Sub-watersheds Number | Tributary Name | Drainage Area Acreage | Drainage Area Square Miles |
|---|---|---|---|
| BL-1 | Ramshorn Brook | 33,373 | 52.14 |
| BL-2 | Blackstone River | 28,451 | 44.45 |
| BL-3 | Quinsigamond River | 25,067 | 39.17 |
| BL-4 | Blackstone River | 31,718 | 49.56 |
| BL-5 | Mumford River | 36,430 | 56.92 |
| BL-6 | West River | 23,722 | 37.06 |
| BL-7 | Mill River | 28,173 | 44.02 |
| BL-8 | Abbott Run | 7,383 | 11.54 |
|  |  | 214,317 (acres) | 334.86 (sq. miles) |

Source: U.S. Dept. of Agriculture-Soil Conservation Service, Mass. Water Resources Study Area Measurements, Amherst MA 1972.

A map of the Blackstone River Basin and its sub-watersheds is shown in Figure 4.

FIGURE 3

# RIVER BASINS for WATER RESOURCES PLANNING



River Basins

1. Hudson
   a. Hoosic
   b. Kinderhook
   c. Bashbish
2. Housatonic
3. Deerfield
4. Westfield
5. Farmington
6. Connecticut
7. Millers
8. Chicopee
9. Quinebaug
10. French
11. Nashua
12. Blackstone
13. Merrimack
14. Concord
    a. Assabet
    b. Concord & Sudbury
15. Shawsheen
16. Parker
17. Ipswich
18. North Coastal
19. Boston Harbor
    a. Mystic
    b. Neponset
    c. Weymouth & Weir
20. Charles
21. South Coastal
    a. North & South Rivers
    b. South Coastal Shore
22. Cape Cod
23. Islands
24. Buzzard's Bay
25. Taunton
26. Narragansett Bay & Mt. Hope Bay Shore
27. Ten Mile

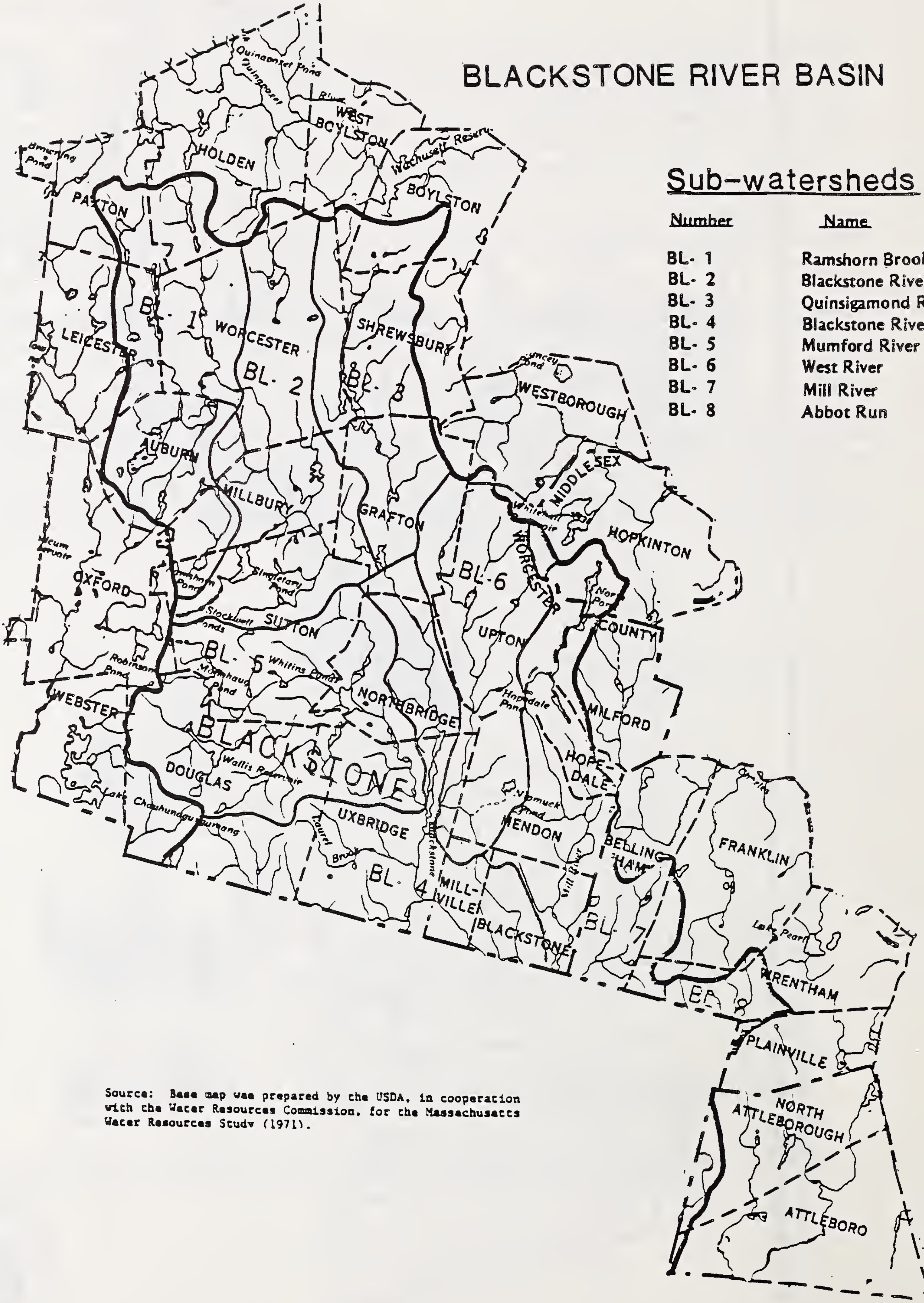
Basin Boundary ————

Sub-Basin Boundary ---------

Executive Office of Environmental Affairs • Water Resources Commission

Prepared by Division of Water Resources (D.E.M.)

FIGURE 4



Source: Base map was prepared by the USDA, in cooperation with the Water Resources Commission, for the Massachusetts Water Resources Study (1971).

## IV. Study Area

The Blackstone Study Area includes eighteen communities with land area in the basin. These communities are Auburn, Bellingham, Blackstone, Boylston, Douglas, Grafton, Hopedale, Leicester, Mendon, Millbury, Millville, North Attleboro, Northbridge, Shrewsbury, Sutton, Upton, Uxbridge and Worcester.

Seventeen communities use the Blackstone Basin as a source for all or some of their public water supply. The portion of Mendon with public water supply is serviced by the Milford Water Company whose sources are in the Charles River Basin. Millville has no public water supply system.

Holden, Hopkinton, North Attleboro, Paxton and Wrentham have small sections of their land area, but no public water supply sources, in the Blackstone Basin. These five communities have one or more non-domestic, self-supplied sources in the Blackstone and are included in this report under existing and projected self-supplied water demand in the Blackstone Basin. To the best of our knowledge, none of these towns has plans to develop public water supply sources in the Blackstone.

Several other towns have small sections of land within the basin but currently obtain little, if any, water supply from the Blackstone. Franklin, Milford, Oxford, Plainville, Webster, West Boylston and Westborough fall into this category and are not included in the Blackstone Study Area.

No community located entirely outside of the Blackstone Basin has water supply sources within the basin.

Table 1 lists all communities with any land area in the Blackstone Basin, and Figure 5 is a map showing communities in the Blackstone Study Area.

# TABLE 1

## Land Area of Communities in Blackstone Basin

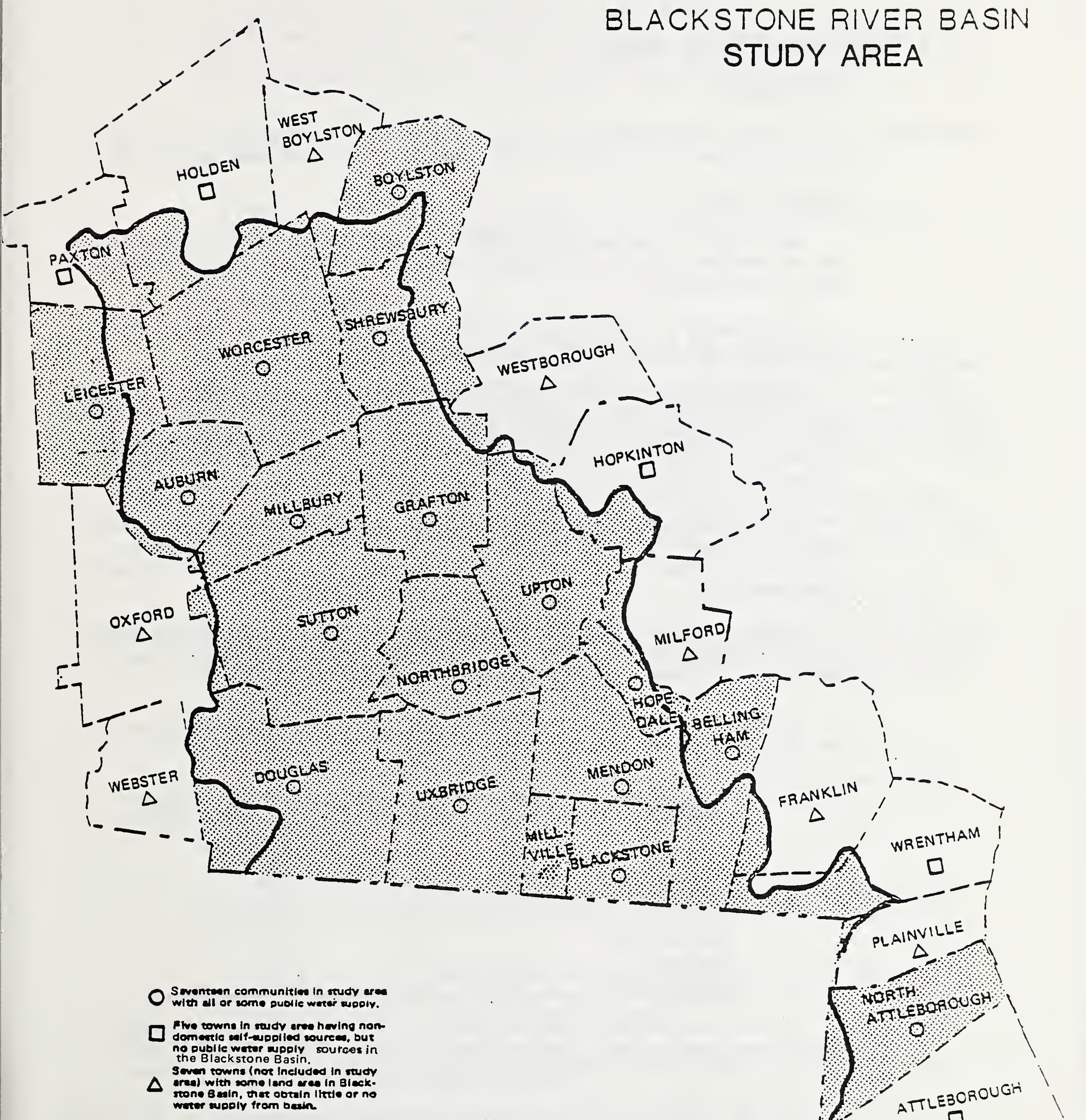
| Community | Percent of Land Area in Blackstone | More than 50 Percent Land Area in Blackstone | All or Some Public Water Source in Blackstone | Significant Self-supplied Sector in Blackstone | Notes |
|---|---|---|---|---|---|
| (Attleboro) | 3.78 | | | X | some industrial self-supplied in Blackstone. |
| Auburn | 92.89 | X | X | | |
| Bellingham | 47.93 | | X | | |
| Blackstone | 100 | X | X | | |
| Boylston | 19.94 | | X | X | |
| Douglas | 86.30 | X | X | | |
| (Franklin) | 9.56 | | | | self-supplied domestic less than 100 people in Blackstone. |
| Grafton | 93.22 | X | X | | |
| (Holden) | 18.71 | | | X | some domestic self-supplied in Blackstone. Worcester's reservoirs located in Holden. |
| Hopedale | 80.81 | X | X | | |
| (Hopkinton) | 13.97 | | | X | some domestic self-supplied in Blackstone. |
| Leicester | 33.09 | | X | | |
| Mendon | 98.04 | X | | X | 14% of pop. served by Milford in the Charles Basin. 86% self-supplied. |
| (Milford) | 13.80 | | | | self-supplied domestic less than 100 people in Blackstone. |
| Millbury | 99.68 | X | X | | |
| Millville | 100 | X | | X | no central supply. |
| Northbridge | 100 | X | X | | |
| N. Attleboro | 20.63 | | X | | Kings Grant Estates wells located in Blackstone. |
| (Oxford) | 4.79 | | | | self-supplied domestic less than 100 people in the Blackstone |
| (Paxton) | 24.02 | | | X | some domestic self-supplied in Blackstone. Some of Leicester's wells & Worcester's reservoirs located in Paxton. |
| (Plainville) | 9.39 | | | | self-supplied domestic less than 100 people in Blackstone. |
| Shrewsbury | 64.68 | X | X | | |
| Sutton | 98.09 | X | X | | |
| Upton | 95.90 | X | X | | |
| Uxbridge | 100 | X | X | | |
| (Webster) | 0.88 | | | | |
| (West Boylston) | 9.56 | | | | |
| (Westboro) | 2.67 | | | | |
| Worcester | 99.30 | X | X | | |
| (Wrentham) | 25.82 | | | X | some domestic self-supplied in Blackstone. |

Key:

Auburn -- Study Area Community

(Franklin) -- Less than 50 percent of land area and no public water supply sources in the Blackstone.

FIGURE 5



BLACKSTONE RIVER BASIN
STUDY AREA

WEST BOYLSTON
HOLDEN
BOYLSTON
PAXTON
SHREWSBURY
WORCESTER
WESTBOROUGH
LEICESTER
HOPKINTON
AUBURN
MILLBURY
GRAFTON
UPTON
OXFORD
SUTTON
MILFORD
NORTHBRIDGE
HOPE DALE
BELLING HAM
WEBSTER
DOUGLAS
MENDON
UXBRIDGE
FRANKLIN
MILL VILLE
BLACKSTONE
WRENTHAM
PLAINVILLE
NORTH ATTLEBOROUGH
ATTLEBOROUGH
○ Seventeen communities in study area with all or some public water supply.
□ Five towns in study area having non-domestic self-supplied sources, but no public water supply sources in the Blackstone Basin.
△ Seven towns (not included in study area) with some land area in Blackstone Basin, that obtain little or no water supply from basin.

## V. Public Water Supply Systems

### 1. 1980 Demand

Public water supply system customers are the primary water users in the Blackstone Basin with a 1980 average day demand (ADD) of 39 mgd.

Summary Points

- In 1980, 89 percent or 282,643 of the 320,042 people living in the Blackstone Study Area obtained their water supply from a public water supply system.

- The basin's public water supply systems provided 17 mgd to area industries and commercial establishments.

- Seventeen Blackstone Basin communities are served, totally or in part, by a public water supply system. Millville and Mendon do not have public water supply systems, although a small section of Mendon is served by the Milford Water Company in Milford (Charles River Basin). Millville is planning to establish a public water system before 1990.

- The Blackstone Basin communities are served by 28 separate water supply systems; 13 of these are fire and water districts, 4 are independently-owned water supply utilities and 11 are city or town water departments.

- Public water supply system customers are the primary water users in the Blackstone Basin. The 1980 average day demand (ADD) of the Basin's public water supply systems was 39 mgd.

- Seven communities had a 1980 water use of one million gallons per day or more. (see list below)

| Community | 1980 Average Day Demand (mgd) |
|---|---|
| Worcester | 25.7 |
| Shrewsbury | 2.6 |
| North Attleboro | 2.6 |
| Millbury | 1.2 |
| Northbridge | 1.1 |
| Auburn | 1.1 |
| Bellingham | 1.0 |

- The Worcester water supply system is by far the largest in the Blackstone basin with a 1980 average day demand of 25.7 mgd. This amount is 66 percent of the total 1980 public water supply demand.

- If the 1980 maximum day demand for all basin communities had occurred on the same day in 1980, the total amount of water used by the public water supply system would have been 59 mgd.

- Worcester and the neighboring towns of Auburn, Grafton, Millbury, and Shrewsbury have a combined 1980 average day demand of 31.3 mgd. These communities comprise about one-third of the basin's land area but use 80 percent of the total 1980 public water supply demand.

- Appendix 1 lists the public water supply systems serving the Blackstone Basin.

- Table 2 lists the 1980 average and maximum day demand for each community in the Blackstone Basin.

Sources of Data

Water demand figures were obtained from the 1980 "Water Supply Statistics Report" submitted by each water supply agency to the regional offices of the Division of Water Supply in the Department of Environmental Quality Engineering (DEQE). These figures were confirmed by the Division of Water Resources - "Municipal Water Resources Management Plan-Phase II questionnaire" responded to by the water supply agencies in 1982.

The 1980 average day demand was calculated by dividing the 1980 water consumption (in gallons) by 366 days (1980 was a leap year). The above calculations produced a base unit figure of a million gallons per day (mgd).

The demand figures in Table 2 are the aggregate of water demand for all the public water supply systems serving a community. Water provided by a water supply system to individual customers or another system in adjoining communities is included in the demand figures of the community where the supplier is located.

### 2. 1980 Source of Supply

More than one-half of the Blackstone Basin's public water supply comes from sources located outside of the basin.

Summary Points

- Basin communities obtained more of their public water supply from sources outside of the Blackstone Basin than from sources within the basin.

- Of the basin's 1980 average day demand of 39.1 mgd, 55 percent or 21.5 mgd came from out-of-basin sources and 45 percent or 17.6 mgd came from sources located in the Blackstone Basin.

- The Worcester water supply system used 17.3 mgd or 77 percent of 21.5 mgd from out-of-basin sources.

- In 1980 Worcester's ADD was 25.7. Of this amount, 8.4 mgd came from sources in the Blackstone Basin and 17.3 mgd came from the Nashua Basin.

## TABLE 2

### Public Water Supply Systems
### 1980 Average Day Demand and Maximum Day Demand
### (in million gallons per day)

| Community | Average Day Demand | Maximum Day Demand |
|---|---|---|
| Auburn | 1.07 | 1.84 |
| Bellingham | 1.04 | 2.23 |
| Blackstone | 0.37 | 0.63 |
| Boylston | 0.25 | 0.38 |
| Douglas | 0.18 | 0.46 |
| Grafton | 0.82 | 1.26 |
| Hopedale | 0.55 | 0.61 |
| Leicester | 0.66 | 1.21 |
| Mendon | 0.03 | 0.04 |
| Millbury | 1.16 | 1.62 |
| Millville | No Central Supply | |
| Northbridge | 1.14 | 1.65 |
| N. Attleboro | 2.58 | 4.73 |
| Shrewsbury | 2.56 | 4.44 |
| Sutton | 0.12 | 0.17 |
| Upton | 0.23 | 0.38 |
| Uxbridge | 0.69 | 1.13 |
| Worcester | 25.67 | 35.90 |
| Total | 39.12 mgd | 58.68 mgd |

Source: Municipal Water Resources Management Plan Phase II Questionnaires and Division of Water Supply (DEQE).

- Worcester has a contract with the Metropolitan District Commission for an additional 10 mgd of water from out-of-basin sources that it did not use in 1980.

- Nine basin communities obtain all of their public water supply from sources in the Blackstone Basin.

- The six river basins furnishing water to public water supply systems in the Blackstone Basin in 1980 are listed below:

| Basin | Volume of ADD Supplied | Percent |
|---|---|---|
| Blackstone | 17.58 | 45 |
| Nashua | 17.47 | 45 |
| Ten Mile | 2.55 | 7 |
| Charles | .89 | 2 |
| French | .49 | 1 |
| Assabet | .14 | negligible |
| | 39.12 mgd | 100% |

Table 3 lists in mgd the portion of each community's average day demand obtained from the various river basins in 1980.

Appendix 2 is an explanation of the process used to identify and locate public water supply sources.

Sources of Data

Each of the Municipal Water Resources Management Plan - Phase II questionnaires included a map showing the location of the water supply system's sources. Using this information, sources were located in the respective basins. The portions of the 1980 ADD supplied by each source were aggregated to give basin totals.

For example, the Town of Leicester has three water supply districts. The Leicester Water Supply District has four wells in the section of Paxton located in the Blackstone Basin. The portion of Leicester's total 1980 ADD furnished by these sources was 0.17 mgd. The two other public water supply districts in Leicester have their water supply sources in the section of Leicester in the French River Basin. Thus, of Leicester's total demand of 0.66 mgd, 0.17 mgd came from sources in the Blackstone and approximately 0.49 mgd from sources in the French River Basin.

## 3. 1980 Type of Supply

Surface water is the major source of supply for the large urban Worcester system while groundwater is the main source for suburban and rural communities in the basin.

## TABLE 3

### Public Water Supply
### 1980 Source of Supply by Basin
### (all figures in mgd)

| Community | Blackstone | Nashua | French | Concord-Sudbury | Charles | Assabet | Ten-Mile | Taunton | 1980ADD* |
|---|---|---|---|---|---|---|---|---|---|
| Auburn | 1.07 | | | | | | | | 1.07 |
| Bellingham | 0.47 | | | | 0.57 | | | | 1.04 |
| Blackstone | 0.37 | | | | | | | | 0.37 |
| Boylston | 0.10 | 0.15 | | | | | | | 0.25 |
| Douglas | 0.18 | | | | | | | | 0.18 |
| Grafton | 0.82 | | | | | | | | 0.82 |
| Hopedale | 0.26 | | | | 0.29 | | | | 0.55 |
| Leicester | 0.17 | | 0.49 | | | | | | 0.66 |
| Mendon | | | | | 0.03 | | | | 0.03 |
| Millbury | 1.16 | | | | | | | | 1.16 |
| Millville | No Central Supply | | | | | | | | |
| Northbridge | 1.14 | | | | | | | | 1.14 |
| N. Attleboro | 0.03 | | | | | | 2.55 | | 2.58 |
| Shrewsbury | 2.42 | | | | | 0.14 | | | 2.56 |
| Sutton | 0.12 | | | | | | | | 0.12 |
| Upton | 0.23 | | | | | | | | 0.23 |
| Uxbridge | 0.69 | | | | | | | | 0.69 |
| Worcester | 8.35 | 17.32 | | | | | | | 25.67 |
| Total: | 17.58 | 17.47 | 0.49 | -- | 0.89 | 0.14 | 2.55 | | 39.12 mgd |

*Total 1980 Average Day Demand

Source: Municipal Water Resources Management Plan-Phase II Questionnaires

## Summary Points

- Four basin communities obtain a portion of their public water supply from surface sources. These communities are: Hopedale (8 percent), Mendon (46 percent), Leicester (48 percent) and Worcester (95 percent).

- Worcester is the largest surface water user in the basin with a 1980 ADD of 24.4 mgd from surface sources. This represents 98 percent of the 24.8 mgd surface water used by the basin's public water supply systems.

- Surface sources supplied 63 percent of the water used by public water supply systems in 1980.

- All eighteen basin communities obtain a portion of their water supply from groundwater sources. Groundwater use ranges from 5 percent in Worcester to 100 percent for many of the other communities.

- Thirteen communities obtain one hundred percent of their public water supply from groundwater sources. One community obtains more than 90 percent, while two others obtain more than 50 percent from groundwater sources. Worcester obtains but 5 percent from groundwater while Millville obtains all of its water supply from on-site groundwater sources.

- Groundwater sources supplied 37 percent of the water used by public water supply systems in 1980.

- Table 4 lists the amounts and percentages of the basin communities' 1980 average day demand from surface and groundwater sources. The figures represent each community's total 1980 water use from sources located both in the Blackstone and other basins.

## Sources of Data

Each water supply system's 1980 surface and groundwater use was determined from the Municipal Water Resources Management Plan - Phase II questionnaires. In response, each water supply agency listed the percentage of the system's 1980 water use obtained from different sources. This percentage was multiplied by the system's 1980 ADD to obtain an approximate percentage of the average day demand furnished by surface and groundwater sources. In communities with more than one water supply system this information was aggregated to arrive at a community total.

The data for the four communities with both surface and groundwater sources was checked carefully to ensure that the percentage was accurate. In cases where the information was not available, the percentages were estimated.

## TABLE 4

### Public Water Supply Systems
### Type of Water Supply
### (in million gallons per day)

| Community | 1980 Average Day Demand | Percent Surface Water Use | 1980 Surface Water Use(mgd) | Percent Ground-water Use | 1980 Ground-water Use(mgd) |
|---|---|---|---|---|---|
| Auburn | 1.07 | -0- | -0- | 100% | 1.07 |
| Bellingham | 1.04 | -0- | -0- | 100% | 1.04 |
| Blackstone | 0.37 | -0- | -0- | 100% | 0.37 |
| Boylston | 0.25 | -0- | -0- | 100% | 0.25 |
| Douglas | 0.18 | -0- | -0- | 100% | 0.18 |
| Grafton | 0.82 | -0- | -0- | 100% | 0.82 |
| Hopedale | 0.55 | 8% | 0.04 | 92% | 0.51 |
| Leicester | 0.66 | 48% | 0.32 | 52% | 0.34 |
| Mendon | 0.03 | 46% | 0.01 | 54% | 0.02 |
| Millbury | 1.16 | -0- | -0- | 100% | 1.16 |
| Millville | No Central Supply | | | | |
| Northbridge | 1.14 | -0- | -0- | 100% | 1.14 |
| N. Attleboro | 2.58 | -0- | -0- | 100% | 2.58 |
| Shrewsbury | 2.56 | -0- | -0- | 100% | 2.56 |
| Sutton | 0.12 | -0- | -0- | 100% | 0.12 |
| Upton | 0.23 | -0- | -0- | 100% | 0.23 |
| Uxbridge | 0.69 | -0- | -0- | 100% | 0.69 |
| Worcester | 25.67 | 95% | 24.39 | 5% | 1.28 |
| Total: | 39.12 | 63% | 24.76 | 37% | 14.36 mgd |

Source: Municipal Water Resources Management Plan-Phase II Questionnaires

## 4. Public Water Supply Systems - 1980 Type of Water Use

The water supplied in 1980 by the public water supply system in the Blackstone Basin was utilized in the following manner:

| | |
|---|---|
| Residential | 42% |
| Industrial | 32% |
| Commercial | 12% |
| Unaccounted | 10% |
| Other | 3% |
| Agriculture | Less than 1% |

### Summary Points

- The major water use in the Blackstone Basin is residential and represents 42 percent of the 1980 total volume furnished by public water supply systems. In Worcester, the industrial water use of 45 percent is greater than the residential water use of 33 percent. In twelve of the eighteen basin communities residential water use is 60 percent or more, and in some of these communities is as high as 90 percent.

- In 1980, industry placed the next largest demand (32 percent) on the basin's public water supply system. Industrial water use was the greatest in Worcester, Millbury and Sutton.

- In 1980, commercial water use was 12 percent in the basin. Auburn's commercial use was the highest percentage and represented 30 percent of the town's 1980 demand.

- Agricultural water use from public water supply systems was minimal throughout the basin. Uxbridge is the only community reporting public water supply use for agriculture.

- Unaccounted-for-water use in the basin is 10 percent. This is the most difficult category of water use to define since its meaning is open to interpretation.

- As a result, different methods were used by local water supply agencies to calculate water use in this category. For example, many small systems include leakage and other uses such as flushing of mains under residential consumption and then list zero in the "unaccounted-for" water category. Other systems have high percentages of "unaccounted-for" water use, because they have a high percentage of unmetered uses assigned to the "unaccounted-for" category.

- In the "other" category, water sold by one water supply system to another accounted for 3 percent of the total 1980 basin water use.

- Table 5 lists the percentages for different types of water use provided by public water supply systems in the Blackstone Basin.

## Water Use Definitions

The definitions for different water uses are as follows:

- Residential - water used by individuals and families in houses, apartments, condominiums, and mobile home parks
- Commercial - water used by business other than industries
- Industrial - water used by industries for processing, cooling, sanitary, etc.
- Agricultural - water used by the farming industry for irrigation or livestock
- Other - water wholesaled to other public water supply systems in or out of the community
- Unaccounted for - unmetered use including water used by municipal buildings, system flushing and maintenance, leakage, fire fighting, etc.

## Sources of Data

The percent distribution of water use for each water supply system was obtained from the 1980 "Water Supply Statistics Report" submitted by the system's superintendent to the regional offices of the Division of Water Supply in the Department of Environmental Quality Engineering (DEQE).

# TABLE 5

## PUBLIC WATER SUPPLY
## DISTRIBUTION OF WATER USE (estimated)
## 1980

| Community | Water Supply Agency | Percent Residential Water Use | Percent Commercial Water Use | Percent Industrial Water Use | Percent Agricultural Water Use | Percent Other Water Use | Percent Unaccounted Water Use | Notes |
|---|---|---|---|---|---|---|---|---|
| Auburn | AUB W DS | 45 | 30 | 5 | 0 | 0 | 20 | |
| | ELM W DS | served by Worcester Water Department | | | | | | |
| | WOOD W DS | served by Worcester Water Department | | | | | | |
| Bellingham | BELL W DP | 72 | 8 | 0 | 0 | 0 | 20 | |
| Blackstone | BLCK W DP | 52 | 1 | 0 | 0 | 1 | 46 | |
| Boylston | BOYL W DS | 44 | 1 | 3 | 3 | 2 | 47 | Morningdale District sources located in Blackstone Basin. |
| | MNDL W DS | 41 | 1 | 0 | 0 | 1 | 57 | |
| Douglas | DOUG W DP | 28 | 0 | 10 | 0 | 0 | 62 | |
| Grafton | M AM W CO | 43 | 15 | 22 | 0 | 10 | 10 | |
| | SGRF W DS | 90 | 5 | 0 | 0 | 0 | 5 | |
| Hopedale | HPDL W DP | 80 | 2 | 8 | 0 | 0 | 10 | Partially supplied by Milford in Charles Basin |
| | MILF W CO | 100 | 0 | 0 | 0 | 0 | 0 | |
| Leicester | CVAL W DS | 57 | 10 | 5 | 0 | 10 | 18 | Leicester W.S. District has sources in Paxton in the Blackstone. |
| | LEIC W DS | 52 | 10 | 0 | 0 | 18 | 20 | |
| | HILL W DS | 100 | 0 | 0 | 0 | 0 | 0 | |
| Mendon | MILF W CO | 100 | 0 | 0 | 0 | 0 | 0 | All public supply from Milford in Charles Basin |
| Millbury | M AM W CO | 29 | 17 | 27 | 0 | 9 | 18 | |
| | MHIL W DS | served by Massachusetts American | | | | | | |
| | OAKW W DS | served by Massachusetts American | | | | | | |
| Millville | | No Central Supply | | | | | | |
| Northbridge | WHIT W CO | 28 | 6 | 12 | 0 | 32 | 22 | |
| | NBRG W DP | served by Whitinsville Water Company | | | | | | |
| N. Attleboro | NATT W DP | 60 | 15 | 15 | 0 | 0 | 10 | Partially supplied by Attleboro Water Department |
| | KINGS GR | 100 | 0 | 0 | 0 | 0 | 0 | |
| | ATTL W DP | — | — | — | — | — | — | |
| Shrewsbury | SHRW W DP | 77 | 10 | 3 | 0 | 0 | 10 | |
| Sutton | MNCH W DS | 86 | 4 | 10 | 0 | 0 | 0 | Partially supplied by by Whitinsville Water Company. |
| | WILK W DS | 64 | 1 | 35 | 0 | 0 | 0 | |
| | WHIT W CO | — | — | — | — | — | — | |
| Upton | UPTN W DP | 90 | 3 | 3 | 0 | 0 | 4 | |
| Uxbridge | UXBR W DP | 81 | 3 | 1 | 0 | 0 | 15 | |
| Worcester | WORC W DP | 33 | 12 | 45 | 0 | 2 | 8 | |
| | Total | 42% | 12% | 32% | △ | 3% | 11% | |

Key:

△ Less than 0.5 percent

Source: 'Water Supply Statistics Report', Division of Water Supply (DEQE)

## VI. Demographic Profile

### 1. 1980 Census - Service Population, and Population Density

Of the 320,042 people living in the Blackstone Basin, 282,643 or 89 percent obtain their water supply from a public water supply system.

Summary Points

- Of the eighteen communities in the Blackstone Basin, Worcester is the only city and the principal population center. Worcester's 161,799 citizens account for more than 50 percent of the basin's population of 320,042.

- Only seven other communities have a population greater than 10,000. Three of these towns (Auburn, Millbury and Shrewsbury) are suburbs of Worcester. The combined population of Worcester and these three communities is 211,126, or 66 percent of the basin's total population. The land area of these communities is 92 square miles and represents 28 percent of the total basin land area of 334 square miles.

- Of the people living in the Blackstone Basin in 1980, 89 percent or 282,643 obtained their water supply from a public water supply system. The other 11 percent are self-supplied from on-site wells.

- Except for Millville, all basin communities have a public water supply system serving all or part of the community.

- Public water supply systems provide water to 100 percent of the population in three basin communities, to 90-99 percent in three other communities, to 50-89 percent in eight communities and between 10-50 percent in the remaining three communities.

- The Worcester water department provides water to 161,799 individuals, or 57 percent of the basin's service population of 282,643.

- The population densities of the basin communities range from a low of 98 people per square mile in Douglas to a high of 4,200 people per square mile in Worcester.

- There are four communities with a population density greater than 900 persons per square mile; Worcester (4,203), North Attleboro (1,084), Shrewsbury (1,039) and Auburn (903). The following chart illustrates the relationship between population, population density and water use:

| Community | 1980 Census Population | Percent of Total Basin Population | Population Density Per Square Mile | 1980 Average Day Demand | Percent of Basin Average Day Demand |
|---|---|---|---|---|---|
| Worcester | 161,799 | 42% | 4,203 | 26 mgd | 66% |
| Shrewsbury | 22,674 | 6% | 1,039 | 3 mgd | 8% |
| N. Attleboro | 21,095 | 5% | 1,084 | 3 mgd | 8% |
| Auburn | 14,845 | 4% | 903 | 1 mgd | 3% |

- Table 6 lists the 1980 federal census population, land area in square miles, the population density per square mile and the 1980 service population for each basin community. The population density figures were calculated by dividing 1980 census population figures by the total area of the communities.

### Sources of Data

The 1980 federal census figures are from the Federal Census publication, *Number of Inhabitants, Massachusetts - 1980 Census of Population*. The 1980 federal census community figures include all persons indicating a particular city or town as their place of residence. Armed Forces members living on a military installation were counted as residents of the community in which the installation is located. College students were counted as residents of the area in which they are living while attending college. Inmates of institutions who ordinarily live there for a considerable period of time were counted as residents of the community where the institution is located.

The 1980 community service population figures were obtained from the Municipal Water Resources Plan - Phase II questionnaire. The service population covers all individuals within the community that receive water from a public water supply system. In the case of communities with more than one public water supply system, the service populations of all systems were added together to obtain a total for the community. For example, Hopedale's 100 percent service population includes 57 percent of the town served by the Hopedale Water Department and 43 percent of the town's population served by the Milford Water Company.

## 2. Population Forecasts

The population of the Blackstone Basin communities is projected to increase 9 percent from 320,042 in 1980 to 350,255 in 2020.

### Summary Points

- In 1960, the population of the basin was 310,266, increasing 5 percent to 325,522 in 1970 and decreasing about 2 percent to 320,042 by 1980.

- The basin's population is projected to decrease less than 1 percent to 319,163 in 1990 and then increase about 3 percent per decade reaching 350,255 in 2020.

- Worcester's population reached a high of 203,486 in 1950 and had a steady decrease during the next thirty years to 161,799 by 1980.

- Worcester's population is projected to decrease to about 149,638 in 1990 and to slowly increase back to the 1980 level of 161,800 in the year 2020.

- All other basin communities are projected to increase their population between 1980 and 2020. The average percentage increase projected for basin communities is 9 percent. Bellingham is projected to have the largest increase of 54 percent while Worcester has the lowest with no increase during this period. Figure 6 shows projected changes from 1940-2020 in Blackstone Basin population.

# TABLE 6

## Blackstone Study Area
## 1980 Population Density

| Community | 1980 Census Population | Area of Municipality in sq. miles | Municipal Population Density(a) | 1980 Service Population |
|---|---|---|---|---|
| Auburn | 14,845 | 16.44 | 903 | 10,651 |
| Bellingham | 14,300 | 18.86 | 758 | 13,871 |
| Blackstone | 6,570 | 11.29 | 582 | 6,110 |
| Boylston | 3,470 | 19.77 | 176 | 3,000 |
| Douglas | 3,730 | 38.08 | 98 | 2,611 |
| Grafton | 11,238 | 23.32 | 482 | 8,142 |
| Hopedale | 3,905 | 5.27 | 741 | 3,905 |
| Leicester | 9,446 | 24.52 | 385 | 6,734 |
| Mendon | 3,108 | 17.94 | 173 | 450 |
| Millbury | 11,808 | 16.39 | 720 | 5,877 |
| Millville | 1,693 | 4.97 | 341 | -- |
| Northbridge | 12,246 | 17.96 | 682 | 10,164 |
| N. Attleboro | 21,095 | 19.45 | 1,084 | 21,095 |
| Shrewsbury | 22,674 | 21.83 | 1,039 | 20,407 |
| Sutton | 5,855 | 33.95 | 172 | 1,426 |
| Upton | 3,886 | 21.81 | 178 | 2,215 |
| Uxbridge | 8,374 | 29.83 | 281 | 4,362 |
| Worcester | 161,799 | 38.50 | 4,203 | 161,799 |
| Total: | 320,042 | 380.18 | 842(avg.) | 282,819 |

(a) The municipal population density is the number of people per square mile.

- The communities projected to have the largest percentage of population increase between 1980 and 2020 are listed below:

| Community | 1980 Population | 2020 Projection | Percent Increase |
|---|---|---|---|
| Bellingham | 14,300 | 22,000 | 54 |
| Sutton | 5,855 | 7,760 | 33 |
| Mendon | 3,108 | 4,023 | 29 |
| Upton | 3,886 | 4,846 | 25 |

- Table 7 lists the census population of the basin communities from 1940 to 1980 and shows the projected growth from 1990 to 2020.

## Projected Service Area Expansion

It is anticipated that public water supply systems not currently serving 100 percent of the district or community will gradually expand their service area population during the planning period. Estimates of service area growth were developed from discussions with local supply systems' managers and from historical experience about the way service areas develop in response to, or anticipation of, population growth within a community.

For planning purposes, it is assumed that:

- Communities with a 100 percent service population in 1980 will remain at 100 percent through the planning period to the year 2020.

- Communities with a 1980 service population of 90 percent or more will increase 5 percent a decade reaching 100 percent by the year 2000.

- Communities with a service population of less than 90 percent will experience service area growth to 1990 at a rate reported by the local water system manager. Service area population is projected to increase by 10 percent per decade from 1990 to the year 2020.

- Communities projected to have the largest increase in service population are listed below:

|  | 1980 Service Population | Projected 2020 Service Population | Increase in Service Population | Percent Increase in Service Population |
|---|---|---|---|---|
| Bellingham | 13,871 | 22,000 | 8,129 | 59% |
| Shrewsbury | 20,407 | 26,619 | 6,212 | 30% |
| Auburn | 10,641 | 16,309 | 5,668 | 53% |
| N. Attleboro | 21,095 | 25,898 | 4,803 | 23% |
| Grafton | 8,142 | 12,612 | 4,470 | 55% |
| Uxbridge | 4,362 | 6,872 | 2,510 | 57% |

Table 8 lists the 1980 and 2020 projected census and service population of the basin communities.

Sources of Data

The population projections used in this report were obtained from the Central Massachusetts Regional Planning Commission, the Metropolitan Area Planning Council, the Southeastern Regional Planning and Economic Development Commission and the Worcester Office of Planning and Community Development. The projections of the regional planning agencies are used because they are the only available projections that: (1) are based on the 1980 Federal Census figures; (2) project to a date beyond 1990; (3) project population at the town and city level; (4) were prepared with specific knowledge of the growth pattern of the individual communities. If detailed population projections had been prepared by municipal planning departments and they differed significantly, as in the case of Worcester, they were used in lieu of the regional projections.

North Attleboro is in the Southeastern Regional Planning and Economic Development District (SRPEDD), Bellingham is in the Metropolitan Area Planning Council region (MAPC) and the other sixteen communities are in the Central Massachusetts Regional Planning Commision region (CMRPC).

The Metropolitan Area Planning Council prepared population projections in five year increments through the year 2010. Population projections for the year 2020 were derived by extending the projected change for the year 2000 to 2010 over the 10 year period 2010 to 2020. The MAPC publication, Interim Population Forecast 1980-2010, January 1982, explains the agency's projection methodology and contains detailed explanatory charts and tables.

The Central Massachusetts Regional Planning Commission and the Southeastern Regional Planning and Economic Development District prepared population forecasts through the year 2000. Population projections for the years 2010 and 2020 were derived by extending the percent change occurring between 1990 and 2000. For example, between 1990 and 2000, the CMRPC forecast that the Town of Sutton's population would increase by 7.4 percent from 6,725 to 7,225. For planning purposes, it was assumed that Sutton's population would increase by one-half of the 1990-2000 rate of increase during the next two decades 2000-2020 or approximately 3.7 percent per decade. The following formula was used to forecast populations for 2010 and 2020.

[Percent change 1990-2000 X 2000 projection + 2000 projection = 2020 projections

$$\frac{\text{2020 projection - 2000 projection}}{2} + \text{projection} = \text{2010 projection}]$$

Example: Town of Sutton

| | |
|---|---|
| 1980 population | 5,855 |
| 1990 forecast | 6,725 |
| 2000 forecast | 7,225 |
| percent change 1990/2000 | 7.4% |

2020 Forecast

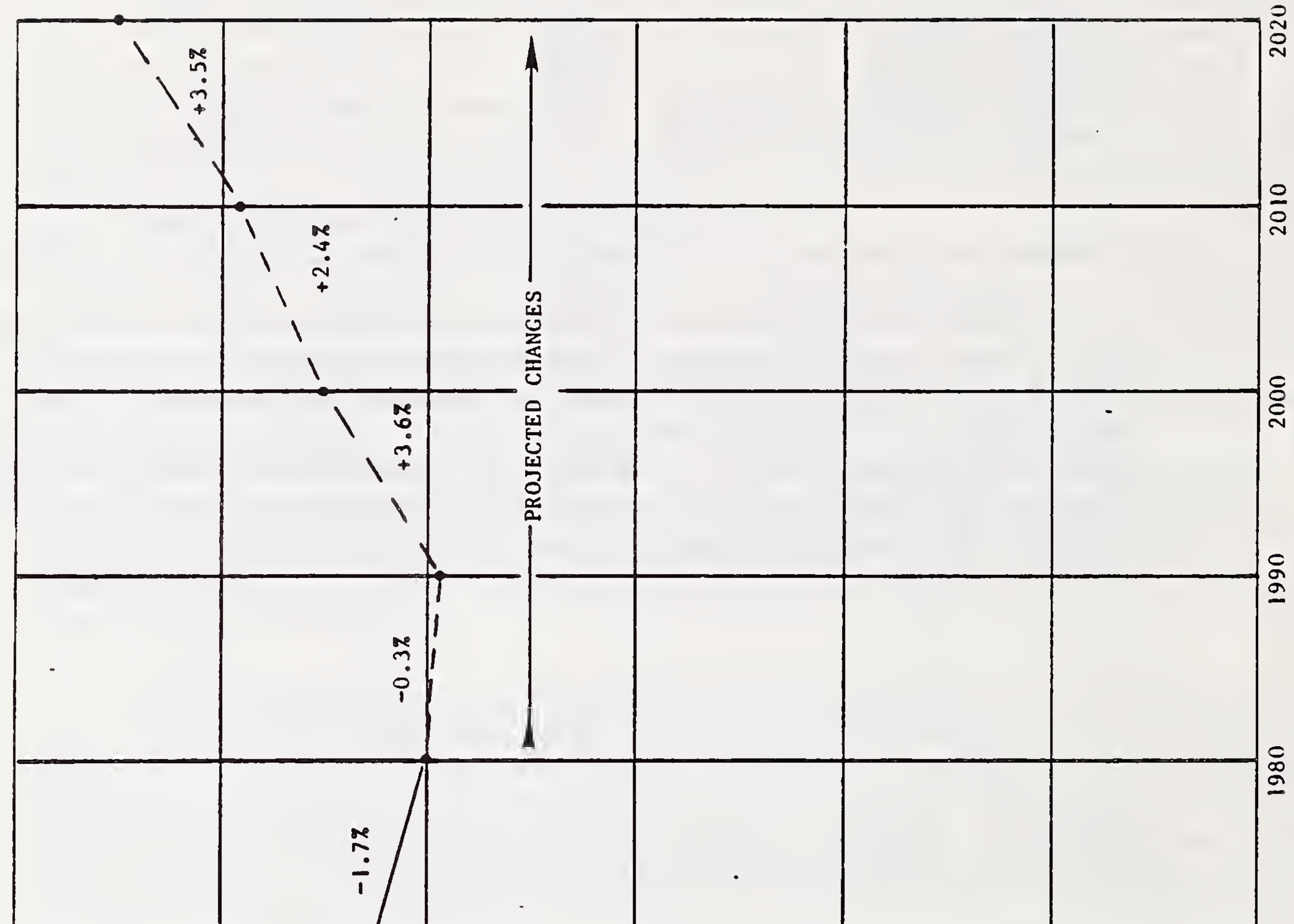
7.4% X 7225 + 7225 = 7760

2010 Forecast

$$\frac{7760 - 7225}{2} + 7225 = 7493$$

The Worcester Office of Planning and Community Development prepared population forecasts for the city and they were used in this report. The city forecasts show a continuing decline in the city's population to 1990, followed by a gradual increase back to the 1980 level by the year 2020. The Central Massachusetts Regional Planning Commission forecasts that Worcester's population would remain constant at the 1980 level through the year 2000.

FIGURE 6



BLACKSTONE BASIN POPULATION - 1940 TO 2020

# TABLE 7

## Population Trends -- Blackstone River Basin

| Community | Federal Census Figures 1940 | 1950 | 1960 | 1970 | 1980 | Projected Changes 1990 | 2000 | 2010 | 2020 | Number Change 1980-2020 | Percent Change 1980-2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Auburn | 6,629 | 8,840 | 14,047 | 15,347 | 14,845 | 15,250 | 15,775 | 16,043 | 16,311 | 1,466 | 10% |
| Bellingham | 2,979 | 4,100 | 6,774 | 13,967 | 14,300 | 17,500 | 19,500 | 20,750 | 22,000 | 7,700 | 54% |
| Blackstone | 4,566 | 4,968 | 5,130 | 6,566 | 6,570 | 6,825 | 7,025 | 7,127 | 7,229 | 659 | 10% |
| Boylston | 1,388 | 1,700 | 2,367 | 2,774 | 3,470 | 3,550 | 3,600 | 3,650 | 3,700 | 230 | 7% |
| Douglas | 2,617 | 2,624 | 2,559 | 2,947 | 3,730 | 3,925 | 4,200 | 4,347 | 4,494 | 764 | 20% |
| Grafton | 7,457 | 8,281 | 10,627 | 11,659 | 11,238 | 11,750 | 12,175 | 12,394 | 12,613 | 1,375 | 12% |
| Hopedale | 3,113 | 3,479 | 3,987 | 4,292 | 3,905 | 4,125 | 4,200 | 4,238 | 4,276 | 371 | 10% |
| Leicester | 4,851 | 6,029 | 8,177 | 9,140 | 9,446 | 9,700 | 10,075 | 10,271 | 10,468 | 1,022 | 11% |
| Mendon | 1,315 | 1,619 | 2,068 | 2,524 | 3,108 | 3,450 | 3,725 | 3,874 | 4,023 | 915 | 29% |
| Millbury | 6,983 | 8,347 | 9,623 | 11,987 | 11,808 | 12,450 | 12,925 | 13,170 | 13,416 | 1,608 | 14% |
| Millville | 1,722 | 1,692 | 1,567 | 1,764 | 1,693 | 1,800 | 1,875 | 1,914 | 1,954 | 261 | 15% |
| Northbridge | 10,242 | 10,476 | 10,800 | 11,795 | 12,246 | 12,650 | 13,225 | 13,522 | 13,820 | 1,574 | 13% |
| N. Attleboro | 10,359 | 12,146 | 14,777 | 18,665 | 21,095 | 22,700 | 24,250 | 25,074 | 25,899 | 4,804 | 23% |
| Shrewsbury | 7,586 | 10,594 | 16,622 | 19,196 | 22,674 | 24,225 | 25,400 | 26,009 | 26,619 | 3,945 | 17% |
| Sutton | 2,749 | 3,102 | 3,638 | 4,590 | 5,855 | 6,725 | 7,225 | 7,492 | 7,760 | 1,905 | 33% |
| Upton | 2,249 | 2,656 | 3,127 | 3,484 | 3,886 | 4,225 | 4,525 | 4,685 | 4,846 | 960 | 25% |
| Uxbridge | 6,417 | 7,007 | 7,789 | 8,253 | 8,374 | 8,675 | 8,850 | 8,938 | 9,027 | 653 | 8% |
| Worcester | 193,694 | 203,486 | 186,587 | 176,572 | 161,799 | 149,638 | 152,000 | 155,000 | 161,800 | 1 | 0% |
| TOTAL | 276,916 | 301,146 | 310,266 | 325,522 | 320,042 | 319,163 | 330,550 | 338,498 | 350,255 | +30,213 | +9% |
| Percent Change |  | +8.7% | +3% | +4.9% | −1.7% | −.3% | +3.6% | +2.4% | +3.5% |  |  |

# TABLE 8

## 2020 Service Population Projections

| | | | | Projected | | |
|---|---|---|---|---|---|---|
| Community | 1980 Census Population | Percent Served | 1980 Service Population | 2020 Projected Population | 2020 Percent Served | 2020 Service Population |
| Auburn | 14,845 | 72 | 10,641 | 16,311 | 100 | 16,311 |
| Bellingham | 14,300 | 97 | 13,871 | 22,000 | 100 | 22,000 |
| Blackstone | 6,570 | 93 | 6,110 | 7,229 | 100 | 7,229 |
| Boylston | 3,470 | 86 | 3,000 | 3,700 | 100 | 3,700 |
| Douglas | 3,730 | 70 | 2,611 | 4,494 | 100 | 4,494 |
| Grafton | 11,238 | 72 | 8,142 | 12,613 | 100 | 12,613 |
| Hopedale | 3,905 | 100 | 3,905 | 4,276 | 100 | 4,276 |
| Leicester | 9,446 | 71 | 6,734 | 10,468 | 100 | 10,468 |
| Mendon | 3,108 | 14 | 450 | 4,023 | 14 | 563 |
| Millbury | 11,808 | 49 | 5,877 | 13,416 | 64 | 8,586 |
| Millville | 1,693 | No Central Supply | | 1,954 | 100 | 1,954 |
| Northbridge | 12,246 | 83 | 10,164 | 13,820 | 100 | 13,820 |
| N. Attleboro | 21,095 | 100 | 21,095 | 25,899 | 100 | 25,899 |
| Shrewsbury | 22,674 | 90 | 20,407 | 26,619 | 100 | 26,619 |
| Sutton | 5,855 | 24 | 1,426 | 7,760 | 32 | 2,483 |
| Upton | 3,886 | 51 | 2,215 | 4,846 | 75 | 3,635 |
| Uxbridge | 8,374 | 52 | 4,362 | 9,027 | 76 | 6,861 |
| Worcester | 161,799 | 100 | 161,799 | 161,800 | 100 | 161,800 |
| Total: | 320,042 | 88% | 282,309 | 350,255 | 95% | 333,311 |

## VII. Projected Water Demands

### 1. Overview

By the year 2020, the average day demand of communities in the Blackstone Study Area will reach an estimated 52 mgd. For planning purposes, public water supply systems will need to be able to supply approximately 67 mgd to residents, businesses, industries and farms in the Blackstone River Basin. This planning figure assumes that towns relying primarily on groundwater will need sufficient water supply sources to provide for their projected maximum day demand.

The demand on public water supply systems is projected to increase for every community in the basin.

The projected demand on public water supply systems is tied directly to changes in population, service area, per capita use and the industrial and commercial sector.

It is assumed that the relative proportion of water used by residents, businesses, industries, agriculture, and other users will not change significantly during the planning period.

Some communities may experience an extraordinary change in water demand during the planning period; thus, altering the projected water use figures. For example, this could be the opening (or closing) of a large water-intensive industry or processing facility. Where this information was known, the anticipated change in water use was added to (or subtracted from) the projected water use for the community.

The methodology for projecting public water supply demand is summarized in Table 9 and explained in detail in appendix 3.

### Summary Points

- The water demand for public water supply systems in the Blackstone Basin, as shown below, will increase between 1980 and 2020:

| | 1980 | 2020 (projected) | Percent Increase |
|---|---|---|---|
| Average Day Demand | 39.12 mgd | 52.12 mgd | 33% |
| Maximum Day Demand | 58.68 mgd | 79.34 mgd | 34% |

- The average day demand of the basin communities is projected to increase from 39.12 mgd to 52.12 mgd, about 33 percent, between 1980 and 2020. This represents an average increase of .8 percent a year over the 40 year period.

- Worcester is projected to have a decrease in water use from 25.67 mgd to 23.99 mgd between 1980 and 1990 and then projected to experience a continuous increase to 30.21 mgd by 2020.

- The communities projected to have the largest percentage and volume increase in water use between 1980 and 2020 are shown below:

| Community | Percent Increase In Water Use | Volume Increase (mgd) in Average Day Demand |
|---|---|---|
| Communities with largest percent increase | | |
| Millville | ** | .18 |
| Sutton | 267% | .32 |
| Uxbridge | 138% | .56 |
| Douglas | 100% | .18 |
| Upton | 87% | .20 mgd |
| Communities with largest volume increase (mgd) | | |
| Worcester | 18% | 4.54 |
| Shrewsbury | 50% | 1.27 |
| North Attleboro | 41% | 1.08 |
| Bellingham | 83% | .86 |
| Auburn | 79% | .84 mgd |

** New water supply system

## 2. Projected Water Demand - Public Water Supply Systems

Projections indicate that all Blackstone Basin communities will experience an increase in water demand between 1980 and 2020.

### Water Demand Projection Assumptions

For planning purposes, the projections should not be regarded as exact numbers, but rather as estimates of future water demand. These estimates are based on the following assumptions representing the division's forecast of what will be occurring during the next 40 years.

The population forecasts prepared by the regional planning agencies and the Worcester Planning Department are sound. The basin will average a 2 percent increase in population per decade during the planning period 1980-2020.

TABLE 9

## Public Water Supply
## Blackstone Study Area Projected Demand

| Community | Average Day Demand | Projected 2020 Average Day Demand | Demand Percent Increase 1980-2020 | Average Day Demand Increase 1980-2020(mgd) | Projected 2020 Maximum Day Demand | Projected 2020 Demand For Planning Purpose |
|---|---|---|---|---|---|---|
| Auburn | 1.07 | 1.91 | 79% | 0.84 | 3.21 | 3.21 |
| Bellingham | 1.04 | 1.90 | 83% | 0.86 | 3.99 | 3.99 |
| Blackstone | 0.37 | 0.50 | 35% | 0.13 | 0.85 | 0.85 |
| Boylston | 0.25 | 0.35 | 40% | 0.10 | 0.53 | 0.53 |
| Douglas | 0.18 | 0.36 | 100% | 0.18 | 0.94 | 0.94 |
| Grafton | 0.82 | 1.45 | 77% | 0.63 | 2.22 | 2.22 |
| Hopedale | 0.55 | 0.69 | 25% | 0.14 | 0.76 | 0.76 |
| Leicester | 0.66 | 1.19 | 80% | 0.53 | 2.15 | 1.19 |
| Mendon | 0.03 | 0.04 | 33% | 0.01 | 0.06 | 0.06 |
| Millbury | 1.16 | 1.97 | 70% | 0.81 | 2.76 | 2.76 |
| Millville | 0 | 0.18 |  | 0.18 | 0.27 | 0.27 |
| Northbridge | 1.14 | 1.76 | 54% | 0.62 | 2.55 | 2.55 |
| N. Attleboro | 2.58 | 3.66 | 41% | 1.08 | 6.74 | 6.74 |
| Shrewsbury | 2.56 | 3.83 | 50% | 1.27 | 6.63 | 6.63 |
| Sutton | 0.12 | 0.44 | 267% | 0.32 | 0.66 | 0.66 |
| Upton | 0.23 | 0.43 | 87% | 0.20 | 0.69 | 0.69 |
| Uxbridge | 0.69 | 1.25 | 138% | 0.56 | 2.04 | 0.04 |
| Worcester | 25.67 | 30.21 | 18% | 4.54 | 42.29 | 30.21 |
| Total: | 39.12 mgd | 52.12 mgd | 33% | 13.00 mgd | 79.34 mgd | 66.30 mgd |

Worcester will continue to experience a decline in population to 1990. Thereafter, a continous increase will occur bringing the population back up to the previous 1980 level by the year 2020. Some of the smaller communities will show a larger increase.

Public water supply service areas will expand during the next 40 years. In communities where more than 90 percent of the population is served, the percentage will increase to 100 percent. Those communities currently under 90 percent will increase 10 percent per decade from 1990 to 2020.

On-going and future conservation efforts have reduced and will continue to reduce water use. While the level of savings differ from community to community, from a statewide perspective, conservation will offset the normal increases in per capita demand throughout this decade. This will result in the gallons per capita day remaining at the 1980 level until 1990. From 1990 to 2020 the gallons per capita day will increase five percent per decade.

## 3. The Projected Year 2020 Water Demand for Planning Purposes

For planning purposes, the 2020 average day demand will be used for communities that receive 50 percent of their water supply from surface water. For communities receiving 50 percent or more of their water supply from groundwater, the projected 2020 maximum day demand will be used. The main reason for using the maximum day demand in the latter case, is that communities that rely largely or entirely on groundwater sources generally lack significant storage capacity and would need to have sufficient supply to meet their projected maximum day demand.

Table 9 lists the 2020 ADD, 2020 MDD and 2020 Demand for planning proposals for the basin communities.

## Water Demand Projection Methodology

A water demand projection methodology that reflects anticipated changes in service population, per capita demand, demand management and characteristics of the individual communities was used to estimate future demand.

Table 10 illustrates the various 2020 Demand components based on the methodology assumptions.

Appendix 3 contains a detailed explanation of each step in the methodology.

Table 11 contains the 2020 Water Demand Projection assumptions.

Table 12 illustrates the 2020 Water Demand Projections.

TABLE 10

## Blackstone Basin
## 2020 Water Demands

| Community | 2020 Service Population | 2020 Base Average Day Demand | 2020 Average Day Demand to Reflect Service Area Expansion | 2020 Average Day Demand Adjusted to Reflect 15 Percent GPCD Increase | 2020 Average Day Demand adjusted to Reflect Other Growth | 2020 Maximum Day Demand | 2020 Demand for Planning Purposes |
|---|---|---|---|---|---|---|---|
| Auburn | 16,311 | 1.18 | 1.66 | 1.91 | 1.91 | 3.21 | 3.21 |
| Bellingham | 22,000 | 1.60 | 1.65 | 1.90 | 1.90 | 3.99 | 3.99 |
| Blackstone | 7,229 | 0.40 | 0.43 | 0.50 | 0.50 | 0.85 | 0.85 |
| Boylston | 3,700 | 0.27 | 0.31 | 0.35 | 0.35 | 0.53 | 0.53 |
| Douglas | 4,494 | 0.22 | 0.31 | 0.36 | 0.36 | 0.94 | 0.94 |
| Grafton | 12,613 | 0.91 | 1.26 | 1.45 | 1.45 | 2.22 | 2.22 |
| Hopedale | 4,276 | 0.60 | 0.60 | 0.69 | 0.69 | 0.76 | 0.76 |
| Leicester | 10,468 | 0.72 | 1.03 | 1.19 | 1.19 | 2.15 | 1.19 |
| Mendon | 563 | 0.03 | 0.03 | 0.04 | 0.04 | 0.06 | 0.06 |
| Millbury | 8,586 | 1.32 | 1.69 | 1.97 | 1.97 | 2.76 | 2.76 |
| Millville | 1,954 | -- | 0.15 | 0.18 | 0.18 | 0.27 | 0.27 |
| Northbridge | 13,820 | 1.26 | 1.52 | 1.76 | 1.76 | 2.55 | 2.55 |
| N. Attleboro | 25,899 | 3.17 | 3.17 | 3.66 | 3.66 | 6.74 | 6.74 |
| Shrewsbury | 26,619 | 2.99 | 3.33 | 3.83 | 3.83 | 6.63 | 6.63 |
| Sutton | 2,483 | 0.29 | 0.38 | 0.44 | 0.44 | 0.66 | 0.66 |
| Upton | 3,635 | 0.29 | 0.38 | 0.43 | 0.43 | 0.69 | 0.69 |
| Uxbridge | 6,861 | 0.74 | 1.08 | 1.25 | 1.25 | 2.04 | 2.04 |
| Worcester | 161,800 | 25.73 | 25.73 | 29.61 | 30.21 | 42.29 | 30.21 |
| Totals: | 333,311 | 41.72 | 44.71 | 51.52 | 52.12 | 79.34 | 66.30 (mgd) |

* Worcester is the only community where the 2020 Average Day Demand was adjusted to reflect other growth.

TABLE 11

## PROJECTION ASSUMPTIONS

### 2020 Water Demand for Public Water Supply Systems

### Blackstone River Basin Study Area

BASIC FORMULA

(2020 Service Population X 2020 GPCD ± (Extraordinary changes in industrial water use) = 2020 ADD

MAJOR PROJECTION ASSUMPTIONS

| 2020 Service Population | 2020 Gallons Per Capita Day (gpcd) | Extraordinary Changes In Industrial Water Use |
|---|---|---|
| 1. 2020 Regional Planning Agency projections | 1. 1980 base gpcd | 1. Increase or decrease in water use because of new or large industrial water users: e.g., new fish processing or computer hardware manufacturing plant, etc. |
| 2. Projection refinements by local planning departments | 2. No increase in gpcd 1980 to 1990 due to conservation | |
| 3. Seasonal population factor | 3. 5% increase in gpcd per decade 1990-2020 | |
| 4. Service Population<br>a. 1990 service population as projected by the cities/towns.<br>b. 1990-2020: 10% increase in percent service population per decade until 100% is reached. | 4. Increase in water use by existing commercial and industrial users reflected in increased GPCD | |

# APPENDIX 1

## Public Water Supply Systems

| Community | Supply Agency | Abbreviation |
|---|---|---|
| Auburn | Auburn Water District | AUB W DS |
| | Elm Hill Water District | ELM W DS |
| | Woodland Water District | WOOD W DS |
| Bellingham | Bellingham Water Department | BELL W DP |
| Blackstone | Blackstone Water Department | BLCK W DP |
| Boylston | Boylston Water District | BOYL W DS |
| | Morningdale Water District | MNDL W DS |
| Douglas | Douglas Water Department | DOUG W DP |
| Grafton | Mass./American Water Company (Grafton Division) | MAM W CO |
| | So. Grafton Water District | SGRF W DS |
| Hopedale | Hopedale Water Department | HPDL W DP |
| | Milford Water Company | MILF W CO |
| Leicester | Cherry Valley & Rochdale Water District | CVAL W DS |
| | Hillcrest Water District | HILL W DS |
| | Leicester Water Supply District | LEIC W DS |
| Mendon | Milford Water Company | MILF W CO |
| Millbury | Maple Hillside Water District | MHIL W DS |
| | Mass./American Water Company (Millbury Division) | MAM W CO |
| | Oakwood Heights Water District | OAKW W DS |
| Millville | None | |
| North Attleboro | Attleboro Water Department | ATTL W DP |
| | Kings Grant Water Company Inc. | KINGS GR |
| | North Attleboro Water Department | NATT W DP |
| Northbridge | Northbridge Water Department | NBRG W DP |
| | Whitinsville Water Company | WHIT W CO |
| Shrewsbury | Shrewsbury Water Department | SHRW W DP |
| | Worcester Water Department | WORC W DP |
| Sutton | Manchaug Water District | MNCH W DS |
| | Whitinsville Water Company | WHIT W CO |
| | Wilkinsonville Water District | WILK W DS |
| Upton | Upton Water & Sewer Department | UPTN W DP |
| Uxbridge | Uxbridge Water Department | UXBR W DP |
| Worcester | Worcester Water Department | WORC W DP |

# APPENDIX 2

## Process Used to Identify and Locate Massachusetts Public Water Supply Sources

### Introduction

The Water Resources Management Planning Regulations 313: CMR 2.00 were adopted by the Massachusetts Water Resources Commission in 1979 to establish a framework for the development of plans for the river basins of the Commonwealth and a state-wide water resource management plan. The regulations provide for a planning process in which the plans would be based on local, regional and state assessments of water needs and water resources.

This appendix is a product of the data furnished by the local public water supply systems during the inventory and analysis stage of this planning process.

### Report Objectives

The objectives of this report are to:

(1) identify all the water sources of public water supply systems in production or actually under development in January 1983 by the river basin in which the sources are physically located

(2) locate the sources by sub-watershed (See Attachment 2)

(3) list the safe yields of the basin sources as of January 1983

(4) indicate the average daily withdrawal from the basin sources during calendar year 1980

### Map -(See Attachment 1)

The base map was prepared for the Massachusetts Water Resources Study by the Soil Conservation Service (USDA) in cooperation with the Massachusetts Water Resources Commission in 1971. The base map shows the major basin water resources and the basin, sub-watershed and town boundaries.

(1) The heavy solid black line delineates the basin boundary.

(2) The thin solid black line delineates the basin's sub-watersheds which are identified by the large letter and number symbol e.g., BL-64.

(3) The thin broken black line delineates the town boundaries.

The water supply source identifying symbols on the map show the approximate location of the source. Where several sources are in close proximity, the symbols are grouped on the map. For example, the symbol SUa1-3 would indicate that three wells belonging to the Manchaug Water District in Sutton are located close together near the symbol on the map.

Chart -(See Attachment 3)

Location of Source: This column shows the city or town in which the water supply source is physically located. If a town in the basin has no sources within its boundaries, it is so noted in the tables.

Water Supply Agency: The water supply agency which operates the source.

Name of Source: Lists the individual water source (s) located in the town listed in column one.

Safe Yield: The safe yield in mgd is listed for the sources as reported by local water supply agencies in December 1982 in the Municipal Water Resources Management Plan - Phase II questionnaires. In some cases, the safe yield was not reported for individual sources, but the figures were aggregated to produce one figure for the entire system. If no safe yield figure is shown next to a source, it is included in the safe yield figure directly below it.

Average Daily Withdrawal: The 1980 Average Daily Withdrawal in mgd was determined by dividing the 1980 pumpage reported to DEQE by 366 days (1980 is a leap year). If a system's sources are all located within the same community and basin, the average day withdrawal is given for the entire system and not broken down by source. If a system's sources are located in two or more basins or in two or more communities, the average withdrawal was allocated to the respective source community or basin by the percentage that these sources contributed to the average day production. Withdrawal from out-of-basin and out-of-town sources are mentioned in the notes.

Map Symbol: Identifies the water supply sources on the accompanying map. For example, "SUb1" indicates the following:

SU: The town (Sutton) served by the water supply agency that owns the source in question.

b: The water supply agency, (Wilkinsville Water District). Where more than one agency serves the town, a lower case "a" indicates the major supplier, "b" the next largest, and so forth. No lower case letters are shown if only one agency serves the town. (as in Shrewsbury, S1, S2, etc.)

1: The number assigned to each individual source, either a well, wellfield or reservoir. As some water supply agencies have sources in more than one town and/or more than one basin, the identifying numbers for sources within one basin may not be consecutive. For example, Worcester's sources in the Blackstone are numbered W1 to W7 and W11 to W12. Sources W8, W9 and W10 are located in the Nashua Basin and so do not appear on the Blackstone map or tables. They would appear on the Nashua Basin Map and tables.

DEQE No.: The DEQE number identifies the water source according to a system designed by the Department of Environmental Quality Engineering. The numbers convey, in a standard sequence, the town in which the supply source is located (not necessarily the town it serves), the site number and a letter identifying the status of the water supply.

Town Number: All cities and towns in Massachusetts are arranged alphabetically and numbered consecutively 001 (Abington) through 351 (Yarmouth). This number indicates the town in which that water supply is located, not necessarily the town it serves.

Site Number: Each water supply source was consecutively issued a three digit number: 001, 002, 003, etc. Depending on the source of verification for the number, the first of the three digits is either 2 or 3: 200 if verified by USGS, 300 if verified by the town alone. (Also, 200 if verified by both town and USGS). An example of the chronologic pattern (hypothetical) is:

301
302
203
304

Letter Identifier (Status): A Letter Identifier terminates the number for a water supply source. An explanation of the code:

A - Active well

B - Active reservoir

C - Reserve well

D - Reserve reservoir

E - Well not in use

F - Abandoned reservoir

G - Status unknown (All unverified wells are 000G)

H - Contaminated well

I - MDC active reservoir

J - MDC reserve or abandoned well

K - MDC reserve or abandoned reservoir

L - MDC status unknown

M - Spring (All springs are 000M)

N - MDC contaminated well

P - Properly abandoned well

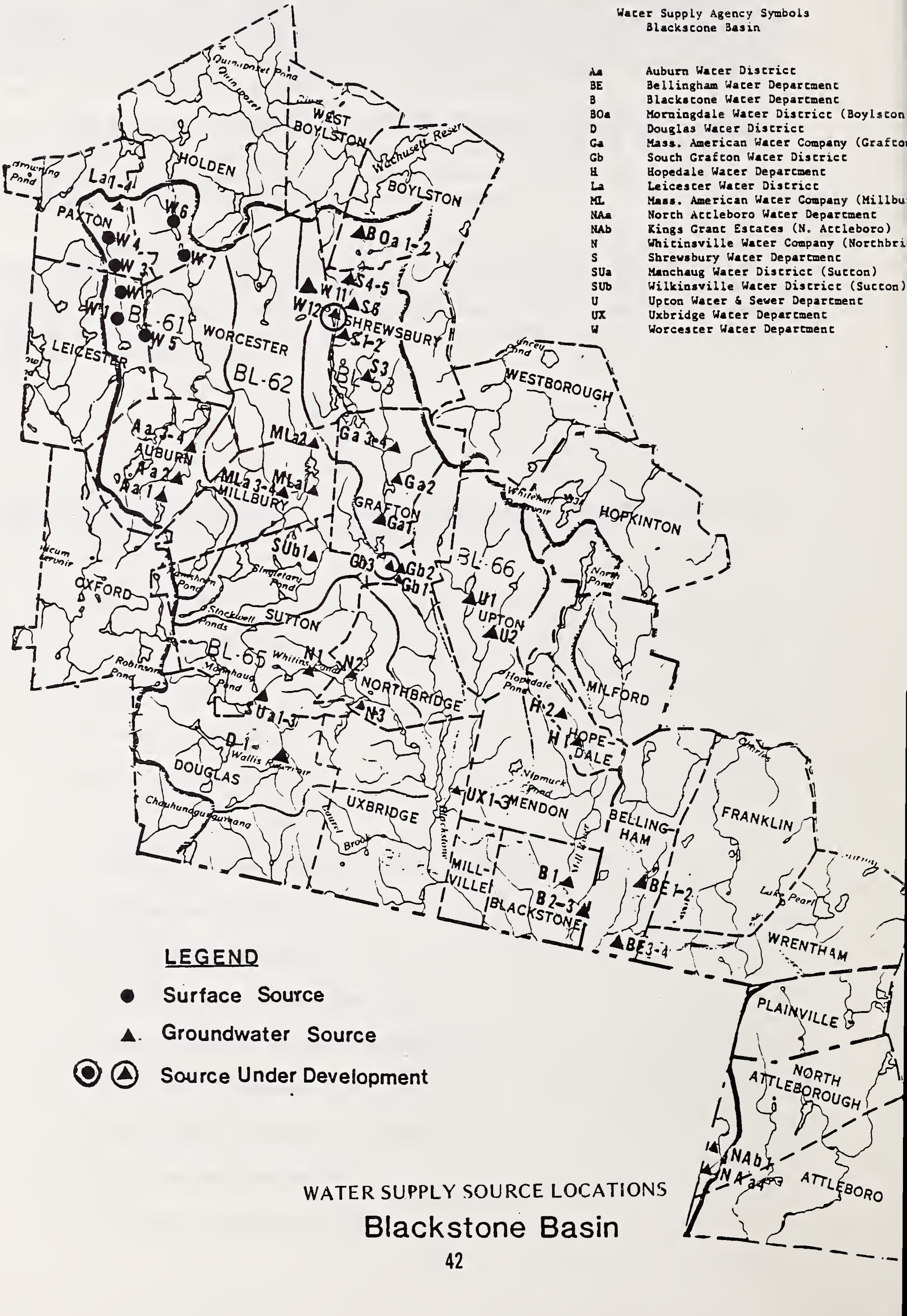
Coordinates: The latitude and longitude numbers are usually given for each individual source, except when two or more sources are in very close proximity. Using these numbers, sources can be located on the USGS 7½ minute series topographic maps of the State.

Notes: Indicates if a system has sources in more than one basin, limitations on the sources listed, etc.

## ATTACHMENT 1

Water Supply Agency Symbols
Blackstone Basin

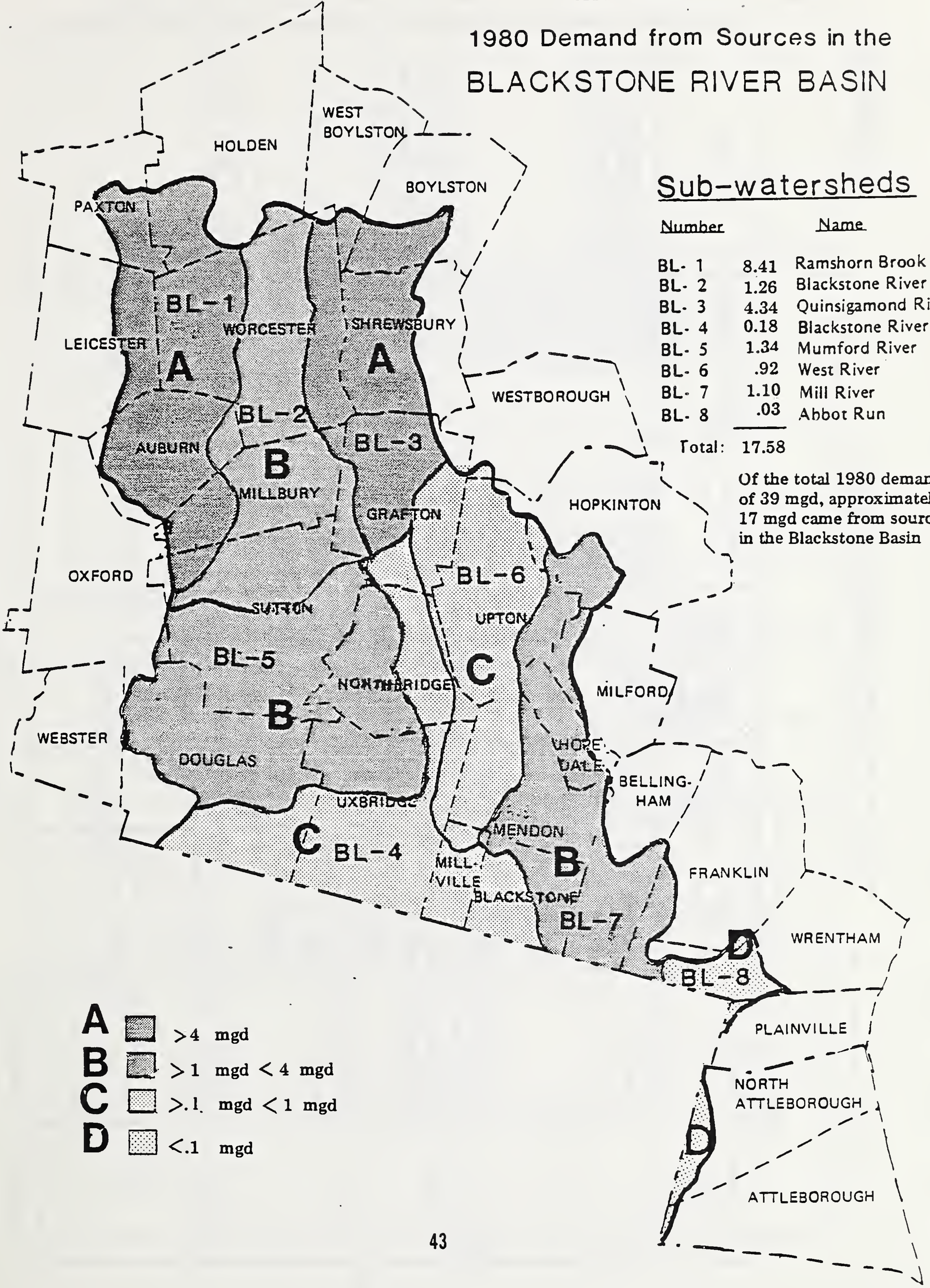
| | |
|---|---|
| Aa | Auburn Water District |
| BE | Bellingham Water Department |
| B | Blackstone Water Department |
| BOa | Morningdale Water District (Boylston |
| D | Douglas Water District |
| Ga | Mass. American Water Company (Grafto |
| Gb | South Grafton Water District |
| H | Hopedale Water Department |
| La | Leicester Water District |
| ML | Mass. American Water Company (Millbu |
| NAa | North Attleboro Water Department |
| NAb | Kings Grant Estates (N. Attleboro) |
| N | Whitinsville Water Company (Northbri |
| S | Shrewsbury Water Department |
| SUa | Manchaug Water District (Sutton) |
| SUb | Wilkinsville Water District (Sutton) |
| U | Upton Water & Sewer Department |
| UX | Uxbridge Water Department |
| W | Worcester Water Department |



WATER SUPPLY SOURCE LOCATIONS
Blackstone Basin

ATTACHMENT 2

## 1980 Demand from Sources in the
## BLACKSTONE RIVER BASIN



### Sub-watersheds

| Number | | Name |
|---|---|---|
| BL- 1 | 8.41 | Ramshorn Brook |
| BL- 2 | 1.26 | Blackstone River |
| BL- 3 | 4.34 | Quinsigamond River |
| BL- 4 | 0.18 | Blackstone River |
| BL- 5 | 1.34 | Mumford River |
| BL- 6 | .92 | West River |
| BL- 7 | 1.10 | Mill River |
| BL- 8 | .03 | Abbot Run |
| Total: | 17.58 | |

Of the total 1980 demand of 39 mgd, approximately 17 mgd came from sources in the Blackstone Basin

# PUBLIC WATER SUPPLY SOURCE LOCATIONS

BASIN Blackstone Page 1 of 6

| Community Location of Source | Water Supply Agency | Name of Source | Safe Yield (mgd) | 1980 Avg. Daily Withdrawal (mgd) | DWR Map Symbol | DEQE No. | USGS No. | Coordinates Latitude Longitude | Notes |
|---|---|---|---|---|---|---|---|---|---|
| Auburn | Auburn Water District | Well #1 | | | Aa 1 | 21A-017- 303A | | 42°11'42"<br>71°50'32" | Woodland Water Dist. (Ab) and Elmhill Water Dist. (Ac) are supplied by the Worcester Water Department |
| | | Well #3 (Church St.) | 1.03 | | Aa 2 | 21A-017-305A | | | |
| | | Well # 6 (Southbridge) | 0.46 | | Aa 3 | 21A-017-302A | | 42°12'30"<br>71°49'56" | |
| | | Well # 4 (Walsh Avenue) | | | Aa 4 | 21A-017-301A | | 42°12'50"<br>71°49'52" | |
| | | Well # 5 (Walsh Avenue) | 1.01 | | Aa 5 | 21A-017-300A | | 42°12'56"<br>71°49'48" | |
| | | | 2.50 | 1.07 | | | | | |
| Bellingham | Bellingham Water Department | Upper Peters R. Well # 1 | | | BE 1 | 41A-025-308A | | 42°03'19"<br>71°28'03" | 0.50 mgd or 55% of the ADD for the Bellingham Water Dept. is derived from sources in the Charles Basin |
| | | Upper Peters R. Well # 2 | 0.35 | | BE 2 | 41A-025-207A | | 42°03'17"<br>71°28'00" | |
| | | Lower Peters R. Well # 3 | | | BE 3 | 41A-025-310A | | 42°01'43"<br>71°28'54" | |
| | | Lower Peters R. Well # 4 | 0.62 | | BE 4 | 41A-025-309A | | 42°01'45"<br>71°28'46" | |
| | | | 0.97 | 0.47 | | | | | |
| Blackstone | Blackstone Water Department | Summer & Park Sts Well # 1 | 0.22 Sta | nd by | B 1 | 21A-032-302A | | 42°02'27"<br>71°31'00" | |
| | | Elm St. Well # 4 | | | B 2 | 21A-032-300A | | 42°02'11"<br>71°30'20" | |
| | | Elm St. Well # 5 | .78 | 0.37 | B 3 | | | | |

# PUBLIC WATER SUPPLY SOURCE LOCATIONS

BASIN_ Blackstone Page 2 of 6

| Community Location of Source | Water Supply Agency | Name of Source | Safe Yield (mgd) | 1980 Avg. Daily Withdrawal (mgd) | DWR Map Symbol | DEQE No. | USGS No. | Coordinates Latitude Longitude | Notes |
|---|---|---|---|---|---|---|---|---|---|
| Boylston | Morningdale Water District | Well # 1 | | | BOa 1 | 21A-039-304A | | 42°20'17"<br>71°44'50" | Boylston Water District (BO b) has sources in the Nashua Basin. |
| | | Well # 2 | .87 | 0.10 | BOa 2 | 21A-039-203A | | 42°20'13"<br>71°44'45" | |
| Douglas | Douglas Water District | Well # 1 | | | D 1 | 21A-077-300A | | 42°04'21"<br>71°43'16" | |
| | | Wellfield | 0.50 | 0.18 | D 2 | 21A-077-301A | | 42°04'10"<br>71°43'17" | |
| Grafton | Mass/American Water Company (Grafton Div.) | Hillbury St. Wells | 0.16 | | Ga 1 | 21A-110-303A | | 42°12'15"<br>71°41'38" | |
| | | Worcester St. Well | 0.76 | | Ga 2 | 21A-110-302A | | 42°13'09"<br>71°41'35" | |
| | | North Grafton Well # 2 | | | Ga 3 | 21A-110-300A | | 42°14'47"<br>71°42'09" | |
| | | North Grafton Well # 3 | 1.24<br>2.16 | 0.64 | Ga 4 | 21A-110-301A | | 42°14'51"<br>71°42'09" | |
| | South Grafton Water District | Providence Rd Well | | | Gb 1 | 21A-110-305A | | 42°10'08"<br>71°40'19" | |
| | | Ferry St. Well # 1 | 0.25 | 0.18 | Gb 2 | 21A-110-304A | | 42°10'27"<br>71°40'14" | |
| | | Proposed Ferry St. Well | (0.53) | | Gb 3 | | | | |

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# PUBLIC WATER SUPPLY SOURCE LOCATIONS

BASIN Blackstone Page 3 of 6

| Community Location of Source | Water Supply Agency | Name of Source | Safe Yield (mgd) | 1980 Avg. Daily Withdrawal (mgd) | DWR Map Symbol | DEQE No. | USGS No. | Coordinates Latitude Longitude | Notes |
|---|---|---|---|---|---|---|---|---|---|
| Holden | Worcester Water Department | Holden Reservoir # 1 | (Totaled<br>tle Broo<br>voir und | with Ket-<br>k Reser-<br>er Paxton) | W 6 | 21A-134-303B | | 42°20'25"<br>71°53'21" | Holden Water Dept. has sources in the Nashua Basin |
| | | Holden Reservoir # 2 | | | W 7 | 21A-134-304B | | 42°18'36"<br>71°52'40" | |
| Hopedale | Hopedale Water Department | Wellfield | 0.42 | 0.26 | H 1 | 21A-138-301A | | 42°06'36"<br>71°31'34" | An additional 0.12 mgd is supplied by the Milford Water Comapny from sources in the Charles Basin |
| | | Well # 1 (standby) | (0.07) | | H 2 | 21A-138-300C | | 42°07'04"<br>71°31'59" | |
| Leicester | Worcester Water Company | Kettle Brook Reservoir # 1 | | | W 1 | 21A-151-304B | | 42°15'30"<br>71°53'30" | Leicester Water Districts (La, Lb, Lc) have sources in the French & Quinebaug and a potential source (Moose Res in the Chicopee Basin |
| | | Kettle Brook Reservoir # 2 | Totaled<br>Paxton | under | W 2 | 21A-151-301B | | 42°16'27"<br>71°54'10" | |
| | | Lynde Brook Res. | | | W 5 | 21A-151-305B | | 42°16'16"<br>71°52'40" | |
| Mendon | None | --- | --- | --- | --- | --- | --- | --- | Mendons supply is obtained from the Milford Water Co. from sources in the Charles Basin |
| Millbury | Mass/American Water Co. (Millbury Div.) | Millbury Avenue Well | 1.03 | | ML a 1 | 21A-186-202A | | 42°12'02"<br>71°45'25" | |

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# PUBLIC WATER SUPPLY SOURCE LOCATIONS

BASIN Blackstone Page 4 of 6

| Community Location of Source | Water Supply Agency | Name of Source | Safe Yield (mgd) | 1980 Avg. Daily Withdrawal (mgd) | DWR Map Symbol | DEQE No. | USGS No. | Coordinates Latitude Longitude | Notes |
|---|---|---|---|---|---|---|---|---|---|
| Millbury (cont.) | | Oak Pond Well | 0.75 | | MLa 2 | 21A-186-300A | | 42°13'26"<br>71°45'16" | |
| | | N. Main St. Well # 1 | | | MLa 3 | 21A-186-303A | | 42°11'59"<br>71°46'22" | |
| | | N. Main St. Well # 2 | 1.33 | | MLa 4 | 21A-186-304A | | 42°11'52"<br>71°46'16" | |
| | | | 3.11 | 1.16 | | | | | |
| Millville | None | --- | --- | --- | --- | --- | --- | --- | No central supply system |
| North Attleboro | North Attleboro Water Department | Adamsville Well | 0.76 | (came on line in '82) | NAa 4 | 21A-211-304A | | 41°55'24"<br>71°22'30" | North Attleboro has water sources yielding on avg. 2.54 mgd located in the Ten Mile Basin |
| | Kings Grant Estates | Longview Drive Well | 0.50 | 0.035 | NAb 1 | 21A-211-303A | | 41°55'55"<br>71°22'20" | |
| Northbridge | Whitinsville Water Company | Whitinsfield Wellfield | 1.35 | | N 2 | 21A-216-301A | | 42°07'00"<br>71°41'30" | Northbridge Water Dept. purchases all water from the Whitinsville Water Company |
| | | G.P. Well # 1 Emergency | 0.38 | | N 3 | 21A-216-302A | | 42°06'28"<br>71°41'11" | |
| | | | 1.73 | 0.59 | | | | | |
| Paxton | Leicester Water District | Well # 1 | | | La 1 | 21A-228-301A | | 42°18'32"<br>71°54'48" | Paxton Water Dept. has sources in the Nashua Basin |
| | | Well # 2 | | | La 2 | 21A-228-303A | | 42°18'24"<br>71°54'47" | |
| | (continued) | Well # 3<br>Well #4 | | | La 3<br>La 4 | 21A-228-304A | | 42°18'29"<br>71°54'40" | |

# PUBLIC WATER SUPPLY SOURCE LOCATIONS

BASIN Blackstone Page 5 of 6

| Community Location of Source | Water Supply Agency | Name of Source | Safe Yield (mgd) | 1980 Avg. Daily Withdrawal (mgd) | DWR Map Symbol | DEQE No. | USGS No. | Coordinates Latitude Longitude | Notes |
|---|---|---|---|---|---|---|---|---|---|
| Paxton (cont.) | | Jim Dandy Well | 0.40 | 0.17 | La 5 | 21A-228-300A | | 42°18'35"<br>71°54'42" | |
| | Worcester Water Department | Kettle Br. Res. # 3 | | | W 3 | 21A-228-306B | | 42°17'10"<br>71°54'40" | |
| | | Kettle Br. Res. # 4 | | | W 4 | 21A-228-305B | | 42°17'52"<br>71°54'45" | |
| | | | 8.84 | 7.17 | | | | | |
| | | | s.y. and ADW includes Worcester sources in Holden and Leicester in Blackstone | | | | | | |
| Shrewsbury | Shrewsbury Water Department | Lamberts # 1 well | 0.462 | Standby | S 1 | 21A-271-302A | | 42°17'30"<br>71°45'12" | An additional 0.14 mgd (5%) is provided by sources in the Assabet Basin |
| | | Lamberts # 2 well | 0.378 | | S 2 | 21A-271-303A | | 42°17'33"<br>71°45'10" | |
| | | Oak St. Well # 3 | 0.378 | | S 3 | 21A-271-203A | | 42°16'00"<br>71°44'55" | |
| | | Sewell St. Well # 4 | 0.664 | | S 4 | 21A-271-300A | | 42°18'26"<br>71°45'07" | |
| | | Sewell St. Well # 5 | 0.420 | | S 5 | 21A-271-301A | | 42°18'28"<br>71°45'07" | |
| | | Homefarm Well #6 | 1.680 | | S 6 | | | | |
| | | | 3.982 | 2.42 | | | | | |
| | Worcester Water Department | Shrewsbury Well | 1.20 | 1.18 | W 11 | | | | |

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# PUBLIC WATER SUPPLY SOURCE LOCATIONS

BASIN Blackstone Page 6 of 6

| Community Location of Source | Water Supply Agency | Name of Source | Safe Yield (mgd) | 1980 Avg. Daily Withdrawal (mgd) | DWR Map Symbol | DEQE No. | USGS No. | Coordinates Latitude Longitude | Notes |
|---|---|---|---|---|---|---|---|---|---|
| Sutton | Whitinsville Water Company | Sutton Wellfield | 0.82 | 0.55 | N 1 | 21A-290-304A | | 42°07'00"<br>71°42'53" | |
| | Manchaug Water District | Well # 1 | | | SUa 1 | 21A-290-301A | | 42°05'57"<br>71°45'00" | |
| | | Well # 2 | | | SUa 2 | 21A-290-302A | | 42°05'55"<br>71°45'00" | |
| | | Well # 3 | 0.45 | 0.02 | SUa 3 | 21A-290-303A | | 42°05'53"<br>71°45'00" | |
| | Wilkinsonville Water District | Hatchery Road G.P. Well | 0.28 | 0.10 | SUb 1 | 21A-290-300A | | 42°10'19"<br>71°44'07" | |
| Upton | Upton Water and Sewer Department | Wellfield | | | U 1 | 21A-303-300A | | 42°10'00"<br>71°37'42" | |
| | | Shaughne Well | 0.69 | 0.23 | U 2 | 21A-303-301A | | 42°09'25"<br>71°36'33" | |
| Uxbridge | Uxbridge Water Department | GP Well # 1 | | | UX 1 | 21A-304-300A | | 42°04'14"<br>71°36'27" | s.y. includes standby well (1.15) and is reduced from 2.49 to 2.10 mgd by distribution system |
| | | GP Well # 2 | | | UX 2 | 21A-304-301A | | 42°04'39"<br>71°36'25" | |
| | | GP Well # 3 | 2.10 | 0.69 | UX 3 | 21A-304-302A | | 42°04'37"<br>71°36'28" | |
| Worcester | Worcester Water Department | Proposed Coal Mine Brook Well | (4.0) | | W 12 | 21A-348-301A | | 42°17'28"<br>71°45'35" | Worcester Water Dept. has sources in the Blackstone Basin in Holden, Leicester & Paxton. An additional 17.3 mgd or 67% of the 1980 ADD is from sources in the Nashua |

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# APPENDIX 3

## Projection Methodology - Blackstone River Basin

The following material explains the methodology used to project water demand for the Blackstone Basin for the period 1990 to 2020. The methodology contains twenty-three steps. The explanation describes the purpose, source of information, mathematical formula, if applicable, and an example of each step. The projected water demands obtained from this methodology are accurate for planning purposes, provided that the assumptions underlying the various steps remain valid. For example, the methodology uses population projections prepared by regional planning agencies. If the actual change in population turns out to be substantially different from these projections, the projected future water demand will be substantially different.

The assumptions in this methodology reflect an assessment of future trends as derived from the literature, consultants' reports, and a review of recent water demand fluctuations and conservation efforts in Massachusetts.

### Blackstone River Basin Methodology For Protecting Water Demand

Step 1 - Community Water Supply Agency
2 - 1980 Federal Census Population
3 - 1980 Percent Service Population
4 - 1980 Base Service Population
5 - 1980 Gallons Per Capita Day (GPCD)
6 - 1980 Average Day Demand (ADD)
7 - 1980 Maximum Day Demand (MDD)
8 - 2020 Population Projections
9 - 2020 Minimum Service Population
10 - 2020 Minimum Average Day Demand
11 - 2020 Increase in Percent Service Population
12 - 2020 Adjusted Service Population
13 - Adjusted 2020 Average Day Demand (ADD) (1)
14 - 2020 Population Projections Refined By Local Input
15 - 2020 Adjusted Service Population
16 - Adjusted 2020 Average Day Demand (ADD) (2)
17 - 2020 Gallons Per Capita Day (GPCD)
18 - Adjusted 2020 Average Day Demand (3)
19 - Significant Changes Anticipated in Water Use
20 - Adjusted 2020 Average Day Demand (4)
21 - 1980 Maximum Day Demand to Average Day Demand Ratio
22 - 2020 Maximum Day Demand
23 - 2020 Demand for Planning Purposes

## Step 1 - Community Water Supply Agency

The Blackstone Basin consists of eighteen communities included for the following reasons:

1. Thirteen towns and one city (Worcester) are designated as Blackstone Basin communities because all or more than 50 percent of their land area lies within the basin boundary.

2. Four communities have some public water supply sources in the Blackstone but have less than 50 percent of their land area in the basin.

No community entirely outside the basin relies on the Blackstone for public water supply. Table 1 lists the communities with land area in the Blackstone Basin.

## Step 2 - 1980 Federal Census Population

The Census population figures were obtained from the 1980 Federal Census of Population and Housing, Massachusetts Final Population and Housing Counts, March, 1981.

The 1980 Federal Census population figure includes all persons who indicated that particular city or town as their usual place of residence. Members of the Armed Forces living on a military installation were counted as residents of the community in which the installation is located; college students were counted as residents of the community in which they were living while attending college; and inmates of institutions who ordinarily live there for a considerable period of time were counted as residents of the community where the institution is located.

## Step 3 - 1980 Percent Service Population

This figure represents the percent of the 1980 Federal Census population that is served by the community central water supply system (s). If a community's 1980 service population is 90 percent, then it is assumed that percentage of the federal census population is on a central supply system and the other 10 percent of the population is self-supplied and relying entirely on individual private wells.

This figure was reported by the local water supply superintendents in the Water Resources Management Plan - Water Supply Element (1980-1981) and confirmed in the Water Resources Management Plan - Phase II questionnaire (1982).

## Step 4 - Base Service Population

1980 Base Service Population consists of three components:

1. Population in the community served by the central water supply system;

The 1980 population served by the central water supply system was obtained by multiplying the 1980 federal census population (Column 2) by the percentage of the population served by the central supply system (Column 3). If only the number of services was known, a factor of 2.5 persons per service was used to estimate the service population.

2. Population outside of community served by the central water supply system;

To the above figure was added any population outside the community served by the central water supply system. This population figure was subtracted from the service population of the community where they live to avoid double counting.

3. Seasonal factor to account for the additional seasonal population in appropriate communities;

In the Blackstone there is no significant seasonal population; thus, this factor was not considered.

Step 5 - 1980 Gallons Per Capita Day (GPCD)

This is the gross gallons per capita day including residential, commercial, institutional, industrial, agricultural and unaccounted-for uses. Large industrial or institutional water use is reflected in a relatively high gpcd figure.

The 1980 per capita consumption figures were calculated by dividing the 1980 Average Day Demand by the 1980 base service population including out-of-town customers and a factor to account for seasonal population.

The 1980 gpcd figures were confirmed by the local water supply superintendents in the Municipal Water Resources Management Plan - Phase II questionnaire (1982).

Step 6 - 1980 Average Day Demand (ADD)

The 1980 Average Day Demand (ADD) was obtained by dividing the 1980 water consumption by 366 (1980 was a Leap Year). The 1980 water consumption figures were obtained from the Division of Water Supply (DEQE) "Water Supply Statistics."

This form is submitted to DEQE by each water supply agency in the spring and reports the total water pumped for the previous calendar year. The figure used from this form was "Net Water Consumption," which is the water pumped from the system's own sources; plus water purchased from other systems, minus water sold to other systems.

The Average Day Demand in units of million gallons per day (mgd), represents the total average daily water consumption including domestic, commercial, institutional, industrial, agricultural, municipal use and unaccounted-for water. Unaccounted-for water includes unmetered water, leakage, fire hydrant use, street washing and distribution system flushing.

The 1980 Average Day Demand figures were confirmed by the local water supply superintendents in the Municipal Water Resources Management Plan - Phase II questionnaires.

## Step 7 - 1980 Maximum Day Demand (MDD)

The 1980 Maximum Day Demand is the largest volume of water pumped during a 24 hour period in that year. The 1980 Maximum Day Demand was obtained from the maximum day consumption figure reported on the Division of Water Supply (DEQE) "Water Supply Statistics" form submitted by the water supply agencies for the calendar year 1980. This figure is given in million gallons per day (mgd).

## Step 8 - 2020 Population Projections

Population projections were obtained from the Regional Planning Agencies (RPA) covering the study area communities: Central Massachusetts Regional Planning Commission (CMRPC), the Southeastern Regional Planning and Economic Development District (SRPEDD) and the Metropolitan Area Planning Council (MAPC). Some adjustments and further projections were made by the Division since the RPA figures did not extend to the year 2020. Population figures for 2010 and 2020 were projected by carrying the 1990-2000 percent change over the 20 year span to 2020. For example, between 1990 and 2000 Sutton's population is projected to increase from 6,725 to 7,225 (7.4 percent). An increase of the same percent was assumed for the next 20 years, or approximately 3.7 percent per decade. The formulas below outline the method used to project populations for 2010 and 2020.

(Percent change 1990-2000) X (2000 projection) + (2000 projection) = 2020 projected.

$$\frac{\text{(2020 projection)} - \text{(2000 projection)}}{2} + \text{(2000 projection)} =$$

2010 projections.

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Example for Sutton:

(7.4% X 7,225) + 7,225 = 7,760 (2020)

7,760 - 7,225 = 535; 535/2=267

267 + 7,225 = 7,492 (2010)

## Step 9 - 2020 Minimum Service Population

The 2020 base service population is the minimum service population which the central water supply system would plan to serve in the year 2020. This figure assumes no extension of the area served and no increase in the seasonal population. The 2020 base service population is the 1980 service population amended only by changes in the permanent population.

This figure was obtained by multiplying the 1980 percent service population (Column 3) by the 2020 population projection (Column 8).

## Step 10 - 2020 Minimum Average Day Demand

The 2020 Minimum Average Day Demand is the minimum average day demand estimated for the communities' central supply system. This figure assumes no changes in the water use pattern of 1980, except for the projected community population change.

This figure was obtained by multiplying the 2020 minimum service population (Column 9) by the 1980 gpcd (Column 5).

## Step 11 - 2020 Increase in Percent Service Population

It is anticipated that in communities where the service population is less than 100 percent of the community's census population, the percentage of people served will increase during the planning period. The estimates of service area growth were developed from discussions with local water supply system managers and from historical experience about the way service areas develop in response to, or anticipation of, population growth within a community.

For planning purposes, it was assumed that:

1. Those communities with a 100 percent service population in 1980 will remain at 100 percent through the planning period to the year 2000.

2. Those communities with a 1980 service population of 90 percent or more will have an increase in service population of 5 percent a decade reaching 100 percent by the year 2000.

3. Those communities with a service population of less than 90 percent were adjusted on an individual basis based upon estimates of service area growth to 1990 reported by the water system managers and then increased by 10 percent per decade until the year 2020.

## Step 12 - 2020 Adjusted Service Population

This figure represents the estimated 2020 service population if the anticipated service area increase occurs.

The figure is obtained by multiplying the 2020 percent service population (Column 11) by the 2020 population projection (Column 8).

## Step 13 - Adjusted 2020 Average Day Demand (ADD) (1)

This figure is the 2020 base average day demand adjusted to reflect the increased water demand resulting from the anticipated service area expansion by the year 2020.

The figure is obtained by multiplying the 1980 gpcd (Column 5) by the 2020 adjusted service population. (Column 12).

## Step 14 - 2020 Population Projections Refined by Local Input

Local planning departments may prepare their own population projections based upon detailed analysis of the dynamics of their community.

The planning departments of the communities in the study area were asked to review the population projections prepared by the regional planning agencies. If, after the review, the planning department felt that their projections were more accurate, the appropriate percentage adjustments were made. For example, the CMRPC projected that Worcester's population would remain at the 1980 level to the year 2000. Other figures provided by the Bureau of Health and modified by the Worcester Office of Planning and Community Development indicated a continuing decline to the year 1990, followed by a rise to the 1980 level by 2020. The population projections for Worcester are adjusted accordingly.

## Step 15 - 2020 Adjusted Service Population

This figure is the 2020 service population adjusted to reflect refinements made to the population based on input from the local planning departments.

This figure is obtained by multiplying the 2020 increase in percent service population (Column 11) by the 2020 population projections refined by local input (Column 15) plus the 1980 additional seasonal population factor.

## Step 16 - Adjusted 2020 Average Day Demand (ADD) (2)

This figure is the base 2020 average day demand adjusted to reflect increased water use resulting from service area expansion and refinements made to community population projections.

This figure is obtained by multiplying the 1980 gpcd (Column 5) by the 2020 adjusted service population (Column 15).

## Step 17 - 2020 Gallons Per Capita Day (GPCD)

The 1980 gpcd (domestic and non-domestic) is held constant through to 1990 if no significant and permanent change occurred in the 1981 or 1982 water use (e.g., a major customer left or entered the community). If some change did occur, then the baseline gpcd is adjusted to the 1981 or 1982 level, and this figure is used for projections to 1990. After this point, a 5 percent increase per decade is applied across the board.

The assumptions underlying these projection methods for gpcd is that major conservation efforts (retrofitting and leak detection) initiated in the past few years and growing in the future will be reflected in a fairly constant gpcd until 1990.

After 1990, savings realized from conservation are assumed to have peaked and gpcd will begin to rise. Also, commercial and industrial growth and expansion are anticipated for the future, increasing gpcd even more.

These two factors will cause gpcd to rise incremently from the year 1990 to 2020, resulting in an increase of 15 percent (5 percent per decade) by 2020 for each community.

This figure is obtained by multiplying the 1980 gpcd (Column 5) by 1.15 (15 percent).

### Step 18 - Adjusted 2020 Average Day Demand (3)

This figure is the base 2020 average day demand adjusted to reflect the increased water demand resulting from service area expansion, local refinements to the population projections and an increase of the gpcd by 15 percent from 1990 to the year 2020.

This figure is obtained by multiplying the 2020 GPCD (Column 17) by 2020 adjusted service population (Column 12).

### Step 19 - Significant Changes Anticipated in Water Use

This column lists one-time adjustments to the estimated 2020 water demand resulting from out-of-the-ordinary changes to the community's water needs. Examples of this would be the construction of a wastewater recovery plant, fish processing plant or the permanent closing of an industry with a large amount of water use.

### Step 20 - Adjusted 2020 Average Day Demand (4)

This figure is the 2020 average day demand adjusted to reflect the changes in water demand resulting from service area expansion, local refinements of population projections, 15 percent increase of gpcd from 1990 to the year 2020 and significant changes anticipated in water use.

This figure is obtained by adding or subtracting significant changes anticipated in water use (Column 19) to or from the adjusted 2020 ADD (3) (Column 18).

### Step 21 - 1980 Maximum Day Demand to Average Day Demand Ratio

The 1980 ratio was calculated by dividing the 1980 Maximum Day Demand by the 1980 Average Day Demand (Column 7 divided by Column 6). It was assumed that the Maximum to Average Day Demand Ratio that exists in 1980 will also exist in 2020.

The 1980 ADD and MDD figures were obtained from the 1982 Water Resources Management Plan - Phase II questionnaires.

Step 22 - 2020 Maximum Day Demand

This figure is obtained by multiplying the adjusted 2020 ADD (4) (Column 20) by the 1980 MDD/ADD ratio (Column 21).

Step 23 - 2020 Demand for Planning Purposes

The 2020 demand for planning purposes was determined in the following manner:

For communities which receive 50 percent or more of their water supply from surface water, the 2020 average day demand (Column 20) is the 2020 demand for planning purposes.

For communities which receive 50 percent or more of their water supply from groundwater, the 2020 maximum day demand (Column 22) is the 2020 demand for planning purposes. Communities which rely largely or entirely on groundwater sources generally lack sufficient storage capacity and need to have sufficient supply to meet their maximum day demand.

# TABLE 12

Blackstone River Basin

2020 WATER DEMAND PROJECTIONS

| Step: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Community | Water Supply Agency | 1980 Census Population | Percent 1980 Census Population Served | 1980 Service Population | 1980 GPCD | 1980 Agency ADD | 1980 Agency MDD | 2020 Projected Population | Minimum 2020 Service Population | 2020 Base ADD | Percent 2020 Census Population Served | Adjusted 2020 Servi Population |
| Auburn | AUB W DS | 14,845 | 64.00 | 9,501 | 113 | 1.07 | 1.84 | 16,311 | 10,439 | 1.18 | 90 | 14,681 |
| | ELM W DS | | 4.00 | 600 | WORC | WORC | WORC | | 652 | WORC | 5 | 815 |
| | WOOD W DS | | 3.50 | 540 | WORC | WORC | WORC | | 570 | WORC | 5 | 815 |
| Bellingham | BELL W DP | 14,300 | 97.00 | 13,871 | 75 | 1.04 | 2.23 | 22,000 | 21,340 | 1.60 | 100 | 22,000 |
| Blackstone | BLCK W DP | 6,570 | 93.00 | 6,110 | 60 | 0.37 | 0.63 | 7,229 | 6,722 | 0.40 | 100 | 7,229 |
| Boylston | BOYL W DS | 3,470 | 40.00 | 1,400 | 107 | 0.15 | 0.23 | 3,700 | 1,480 | 0.16 | 47 | 1,739 |
| | MNDL W DS | | 46.00 | 1,600 | 63 | 0.10 | 0.15 | | 1,702 | 0.11 | 53 | 1,961 |
| Douglas | DOUG W DP | 3,730 | 70.00 | 2,611 | 69 | 0.18 | 0.46 | 4,494 | 3,145 | 0.22 | 100 | 4,494 |
| Grafton | M AM W CO | 11,238 | 47.00 | 5,332 | 120 | 0.64 | 1.02 | 12,613 | 5,928 | 0.71 | 65 | 8,198 |
| | SGRF W DS | | 25.00 | 2,810 | 64 | 0.18 | 0.24 | | 3,153 | 0.20 | 35 | 4,415 |
| Hopedale | HPDL W DP | 3,905 | 57.00 | 2,226 | 170 | 0.38 | 0.42 | 4,276 | 2,437 | 0.41 | 57 | 2,438 |
| | MILF W CO | | 43.00 | 1,679 | 101 | 0.17 | 0.19 | | 1,838 | 0.19 | 43 | 1,838 |
| Leicester | CVAL W DS | 9,446 | 44.00 | 4,200 | 73 | 0.32 | 0.70 | 10,468 | 4,605 | 0.34 | 62 | 6,491 |
| | LEIC W DS | | 23.00 | 2,184 | 85 | 0.19 | 0.33 | | 2,407 | 0.20 | 32 | 3,349 |
| | HILL W DS | | 4.00 | 350 | 440 | 0.15 | 0.18 | | 418 | 0.18 | 6 | 628 |
| Mendon | MILF W CO | 3,108 | 14.00 | 450 | 60 | 0.03 | 0.04 | 4,023 | 563 | 0.03 | 14 | 563 |
| Millbury | M AM W CO | 11,808 | 45.00 | 5,366 | 197 | 1.16 | 1.62 | 13,416 | 6,037 | 1.32 | 59 | 7,915 |
| | MHIL W DS | | 2.60 | 311 | M AM | M AM | M AM | | 348 | M AM | 3 | 402 |
| | OAKW W DS | | 1.70 | 200 | M AM | M AM | M AM | | 228 | M AM | 2 | 269 |
| Millville | NONE | 1,693 | — | — | — | — | 0 | 1,954 | — | — | 100 | 1,954 |
| Northbridge | WHIT W CO | 12,246 | 83.00 | 10,164 | 110 | 1.14 | 1.65 | 13,820 | 11,470 | 1.26 | 100 | 13,820 |
| | NBRG W DP | | WHIT | WHIT | WHIT | WHIT | WHIT | | | | | |
| N. Attleboro | NATT W DP | 21,095 | 93.00 | 19,593 | 130 | 2.54 | 4.64 | 25,899 | 24,086 | 3.13 | 93 | 24,087 |
| | KINGS GR | | 1.30 | 277 | 126 | 0.04 | 0.09 | | 336 | 0.04 | 1 | 336 |
| | ATTL W DP | | 5.70 | 1,225 | NATTL | NATTL | NATTL | | 1,476 | NATTL | 6 | 1,476 |
| Shrewsbury | SHRW W DP | 22,674 | 90.00 | 20,407 | 125 | 2.56 | 4.44 | 26,619 | 23,957 | 2.99 | 100 | 26,619 |
| Sutton | MNCH W DS | 5,855 | 14.00 | 850 | 138 | 0.02 | 0.02 | 7,760 | 1,086 | 0.15 | 18 | 1,396 |
| | WILK W DS | | 7.00 | 400 | 250 | 0.10 | 0.15 | | 543 | 0.14 | 10 | 776 |
| | WHIT W CO | | 3.00 | 176 | WHIT | WHIT | WHIT | | 232 | WHIT | 4 | 311 |
| Upton | UPTN W DP | 3,886 | 57.00 | 2,215 | 1.04 | 0.23 | 0.38 | 4,846 | 2,762 | 0.29 | 75 | 3,635 |
| Uxbridge | UXBR W DP | 8,374 | 52.00 | 4,362 | 158 | 0.69 | 1.13 | 9,027 | 4,694 | 0.74 | 76 | 6,861 |
| Worcester | WORC W DP | 161,799 | 100.00 | 161,799 | 159 | 25.67 | 35.90 | 161,800 | 161,800 | 25.73 | 100 | 161,800 |
| TOTALS: | | 320,042 | | 282,809 | 3,090 | 39.12 | 58.68 | 350,255 | 306,454 | 41.72 | | 333,311 |

# TABLE 12

Blackstone River Basin

2020 WATER DEMAND PROJECTIONS

| 13<br>Adjusted 2020 ADD (1) | 14<br>Community Refinements 2020 Pop. Projections | 15<br>Adjusted 2020 Service Population | 16<br>Adjusted 2020 ADD (2) | 17<br>2020 GPCD | 18<br>2020 ADD Adjusted Population 15 Percent Increase GPCD | 19<br>Significant Changes in Water Use | 20<br>Adjusted 2020 ADD (3) | 21<br>1980 MDD/ADD Ratio | 22<br>2020 Maximum Day Demand | 23<br>2020 Water Demand for Planning Purposes | Community |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.66<br>WORC<br>WORC | *NO ADJUSTMENTS MADE* | | | 130<br>WORC<br>WORC | 1.91<br>WORC<br>WORC | | 1.91<br>WORC<br>WORC | 1.68<br>WORC<br>WORC | 3.21<br>WORC<br>WORC | 3.21<br>WORC<br>WORC | Auburn |
| 1.65 | | | | 86 | 1.90 | | 1.90 | 2.10 | 3.99 | 3.99 | Bellingham |
| .43 | | | | 69 | .50 | | 0.50 | 1.70 | 0.85 | 0.85 | Blackstone |
| .19<br>.12 | | | | 123<br>72 | .21<br>.14 | | .21<br>.14 | 1.50<br>1.50 | 0.32<br>.21 | 0.32<br>0.21 | Boylston |
| .31 | | | | 79 | .36 | | 0.36 | 2.60 | .94 | 0.94 | Douglas |
| .98<br>.28 | | | | 138<br>74 | 1.13<br>.32 | | 1.13<br>.32 | 1.59<br>1.30 | 1.80<br>.42 | 1.80<br>.42 | Grafton |
| .41<br>.19 | | | | 195<br>116 | .48<br>.21 | | .48<br>.21 | 1.10<br>1.10 | 0.53<br>0.23 | 0.53<br>0.23 | Hopedale |
| .47<br>.28<br>.28 | | | | 84<br>98<br>506 | .55<br>.33<br>.31 | | .55<br>.33<br>.31 | 2.20<br>1.80<br>1.14 | 1.21<br>0.59<br>0.35 | .55<br>.33<br>.31 | Leicester |
| .03 | | | | 69 | .04 | | .04 | 1.50 | 0.06 | 0.06 | Mendon |
| 1.69<br>M AM<br>M AM | | | | 226<br>M AM<br>M AM | 1.97<br>M AM<br>M AM | | 1.97<br>M AM<br>M AM | 1.40<br>M AM<br>M AM | 2.76<br>M AM<br>M AM | 2.76<br>M AM<br>M AM | Millbury |
| .15 | | | | | 0.18 | | 0.18 | 1.50 | 0.27 | 0.27 | Millville |
| 1.52 | | | | 127<br>WHIT | 1.76<br>WHIT | | 1.76<br>WHIT | 1.45<br>WHIT | 2.55<br>WHIT | 2.55<br>WHIT | Northbridge |
| 3.13<br>.04<br>NATTL | | | | 150<br>145<br>NATTL | 3.61<br>.05<br>NATTL | | 3.61<br>.05<br>NATTL | 1.83<br>2.57<br>NATTL | 6.61<br>.13<br>NATTL | 6.61<br>.13<br>NATTL | N. Attleboro |
| 3.33 | | | | 144 | 3.83 | | 3.83 | 1.73 | 6.63 | 6.63 | Shrewsbury |
| .19<br>.19 | | | | 159<br>288<br>WHIT | .22<br>.22<br>WHIT | | 0.22<br>0.22<br>WHIT | 1.5<br>1.5<br>WHIT | 0.33<br>0.33<br>WHIT | 0.33<br>0.33<br>WHIT | Sutton |
| .38 | | | | 120 | .43 | | 0.43 | 1.60 | 0.69 | 0.69 | Upton |
| 1.08 | | | | 182 | 1.25 | | 1.25 | 1.63 | 2.04 | 2.04 | Uxbridge |
| 23.73 | | | | 183 | 29.61 | 0.6 | 30.21 | 1.40 | 42.29 | 30.21 | Worcester |
| 44.71 | | | | | 51.52 | 0.6 | 52.15 | | 79.34 | 66.30 mgd | TOTALS: |

# APPENDIX 4

## Summary - Preliminary Estimates of Self-supplied Water Use

As site specific surveys have not been conducted of self-supplied water users, accurate figures for this component of the basin's daily water use have not been compiled and analyzed. That is a task of such dimension that it is beyond the scope of this study.

To begin to understand the extent of self-supplied water use, methods were developed to give preliminary estimates of this factor. The methodologies for estimating residential, commercial, industrial and agricultural self-supplied water use are found in appendices 4A through 4D respectively. Different sources of data were used for each methodology. The water use figures listed below must be considered with the limitations of the source data in mind. The figures should be considered as a minimum level of self-supplied water use in each of these categories. Whether these figures represent 30 percent or 90 percent of the actual self-supplied water use, is not known at this point. The statement that can be made with a relative degree of accuracy is that in 1980, self-supplied water use in the Blackstone Basin was a minimum of 7 mgd.

Preliminary Estimate of the Minimum Level
of 1980 Self-Supplied Water Use
(from sources in the Blackstone)

| | |
|---|---|
| Residential | 2.6 |
| Commercial/Institutional | 0.2 |
| Industrial | 4.3 |
| Agricultural | 0.1 |
| | 7.2 mgd |

RESIDENTIAL SELF-SUPPLIED WATER USE

Approximately 37,000 people or 12 percent of the basin's 1980 population obtained their domestic water supply from self-supplied on-site sources.

Summary Points

- Twelve percent of the basin's population obtained their water supply from self-supplied sources. This percentage will become smaller in the future as the public water supply systems expand their service area and Millville establishes a public water supply system.

- The towns with the largest percentage of people obtaining water from on-site self-supplied sources are Millville with 100 percent, Mendon with 86 percent, Sutton with 79 percent and Millbury with 51 percent.

- Three communities (Worcester, North Attleboro, and Hopedale), have almost no self-supplied residential population. See Table A on Self-supplied residential water use.

## COMMERCIAL/INSTITUTIONAL SELF-SUPPLIED WATER USE

Preliminary estimates of self-supplied commercial/institutional water use indicates a minimum demand level of 0.2 mgd in 1980.

### Summary Points

- For planning purposes it was assumed that this category of water use will remain at the 1980 level through 1990 and then increase about 3 percent per decade to 2020. This is the same percentage increase as projected for public water supply systems. In the absence of any detailed projections, it is believed to be a reasonable assumption.

- An analysis of the data available indicated that the communities with the largest amount of self-supplied commercial/institutional use in 1980 were Auburn, Douglas, Mendon, Millville, Sutton and Uxbridge. Table B lists the study area communities and the estimated commercial/institutional water use in each.

## SELF-SUPPLIED INDUSTRIAL WATER USE

Preliminary estimates of self-supplied industrial water use indicates a minimum demand level of about 4 mgd in 1980.

### Summary Points

- Self-supplied industrial water users represent the largest category of self-supplied water use.

- Preliminary estimates indicate that a minimum of 33 industries obtain water from self-supplied sources.

- Four industries located in Millbury used 2 mgd or 50 percent of the self-supplied industrial water use.

- Twenty-seven of these obtained water from groundwater sources and 6 industries obtained water from surface sources.

- It is anticipated that self-supplied industrial water use will remain constant to 1990 and gradually increase about 3 percent a decade to 2020.

- Table C lists the preliminary estimates of basin communities with self-supplied industrial water users and pertinent summary data.

## AGRICULTURAL SELF-SUPPLIED WATER USE

Preliminary estimates indicate that agricultural self-supplied water use has a minor impact on the water resources of the Blackstone Basin.

## Summary Points

- In 1980, preliminary estimates of agricultural self-supplied water use indicate that the amount was approximately 52 million gallons per year (.14 mgd).
- Of this amount 23 million gallons were used for irrigation; water was withdrawn from streams, ponds, and wells and conveyed and applied to agricultural land, crops and golf courses.
- The remaining 29 million gallons were for livestock drinking water use and water used for cleaning purposes in the dairy operation.
- Cropland irrigation and livestock water use occurred primarily in seven communities: Douglas, Grafton, Mendon, Northbridge, Shrewsbury, Sutton, Uxbridge.
- The U.S. Department of Agriculture forecasts that the agricultural water use in the Blackstone River Basin will remain at approximately the 1980 level through the planning period until the year 2020.
- Table D lists the preliminary estimates of the minimum level of self-supplied agricultural water use for the basin communities in 1980.

## Sources of Data

Appendix 4A, 4B, 4C and 4D contain a detailed explanation of the sources of data and methodology used to make preliminary estimates of self-supplied water use.

# APPENDIX 4A

## Self-supplied Residential Water Use - 1980

Purpose

The purpose of this methodology is to estimate the amount of water used for domestic purposes by residents with individual on-site wells within the hydologic boundaries of the Blackstone Basin in 1980.

Methodology:

Step 1: Approximate the number of self-supplied residents within the study area communities.

In the 1982 Water Resources Management Plan - Phase II questionnaire, each water supply agency manager reported the agency's service population as a portion of the 1980 federal census for the community (s) served. The number of self-supplied residents was estimated by subtracting the service population from the federal census. For example 14 percent of Mendon's population (450 out of 3,108) is served by the Milford Water Company. The remaining 2,658 people (86 percent) are self-supplied.

Step 2: Determine self-supplied water use.

The 1980 self-supplied residential water use was estimated by multiplying the community's self-supplied population by 79 gallons per capita day (gpcd). The gpcd factor was taken from the U.S. Geological Survey's "Estimated Use of Water in the U.S. in 1980," in which the 79 gpcd figure was used to estimate rural self-supplied use. The factor was verified for Massachusetts by comparison with 77 gpcd calculated for water supply systems in the Parker River Basin, an essentially rural area.

Step 3: Determine amount of self-supplied residential water withdrawn from the Blackstone Basin.

For those communities whose land area lies entirely within the Blackstone Basin boundaries, it can be assumed that all self-supplied water is withdrawn from the basin. However, this assumption does not hold for communities lying partially in the basin. In these instances, the water withdrawn from the basin was calculated based on the percentage of the town's land area lying within the basin. On a sub-watershed level, the self-supplied withdrawal was assigned to the subwatershed containing the greatest portion of the town's land area in the Blackstone. For example, 20 percent of Boylston lies in the Blackstone within the Quinsigamond River subwatershed (BL-3). Assuming that self-supplied residents are evenly distributed throughout the town, we can say that 20 percent of them live in the Blackstone Basin. Therefore, Boylston's self-supplied residential water withdrawal from the Blackstone can be calculated by multiplying the percent of the town in the basin times the total self-supplied residential water use for Boylston.

(20% X 0.04 mgd=0.01 mgd from Blackstone Basin)

Since all of Boylston's land area in the Blackstone is in subwatershed BL-3, a withdrawal of 0.01 mgd can be assigned to BL-3. (See Table A - Attachment 4)

ATTACHMENT 4

## TABLE A

## Blackstone Study Area
## Self-supplied Residential Water Use (1980)
## (Preliminary Estimates)

| Community | 1980 Self-supplied Population | Water Use At 79 Gallons Per Capita Day | Percent of Town Area Within The Blackstone Basin | Estimated Self-Supplied Water Use In Blackstone Basin |
|---|---|---|---|---|
| Auburn | 4,204 | 0.33 | 93 | 0.31 |
| Bellingham | 429 | 0.03 | 48 | 0.01 |
| Blackstone | 470 | 0.04 | 100 | 0.04 |
| Boylston | 579 | 0.04 | 20 | 0.01 |
| Douglas | 1,119 | 0.09 | 86 | 0.08 |
| Grafton | 3,096 | 0.24 | 93 | 0.22 |
| Hopedale | 0 | 0 | 81 | 0 |
| Leicester | 2,712 | 0.21 | 33 | 0.07 |
| Mendon | 2,658 | 0.21 | 98 | 0.21 |
| Millbury | 5,931 | 0.47 | 99 | 0.47 |
| Millville | 1,693 | 0.13 | 100 | 0.13 |
| Northbridge | 2,082 | 0.16 | 100 | 0.16 |
| N. Attleboro | 0 | 0 | 21 | 0 |
| Shrewsbury | 2,267 | 0.18 | 65 | 0.12 |
| Sutton | 4,427 | 0.35 | 98 | 0.34 |
| Upton | 1,671 | 0.13 | 96 | 0.12 |
| Uxbridge | 4,012 | 0.32 | 100 | 0.32 |
| Worcester | 0 | 0 | 99 | 0 |
| Total: | 37,352 | | | 2.61 mgd |

Note: For a complete understanding of the meaning or significance of these figures it is necessary to read and follow the methodology described in Appendix 4A.

# APPENDIX 4B

## Self-supplied Commercial and Institutional Water Use
## Blackstone River Basin

### Purpose:

To estimate the amount of commercial and institutional self-supplied water use from sources within the hydrologic boundaries of the Blackstone River Basin in 1980.

Although some operations receive water from both public and self-supplied sources, this report lists only water obtained from the latter. Commercial establishments and institutions served entirely by public water supply are not included.

### Methodology:

Step 1. Generate a list of self-supplied commercial and institutional water users within the Blackstone Study Area

The names and addresses of commercial and institutional self-supplied water users were obtained from the Division of Water Supply(DEQE) Model State Information System - Public Water System Inventory Subsystem, Comprehensive Report (1981 printout) and the Division of Water Resources (DEM) Municipal Water Resources Management Plan, Phase II questionnaire (1982).

Step 2. Categorize users

The wide diversity of self-supplied commercial and institutional users were divided into five categories to facilitate an estimate of their average water use. The categories are as follows:

a) Institutions with a fairly constant resident population; i.e., correctional institutions, hospitals, rehabilitation centers, nursing homes, military bases, colleges, and seminaries. (Note: Elderly housing and municipal housing authorities are not listed here as they are included under residential self-supplied users).

b) Day use in public or quasi-public institutions; i.e., town and private day schools, nursery schools, town offices and departments, museums, libraries and churches.

c) Commercial residential units; i.e., apartments, condominiums and mobile home parks - figures for this category are included in the residential self-supplied users.

d) Business and commercial use; i.e., hotels, motels, inns, restaurants, clubs, taverns, stores, shopping plazas, office buildings, laundries, and car washes. Industries may be included if it appears that self-supplied water is used for sanitary purposes and not for cooling or manufacturing processes.

e) Seasonal recreational use; i.e., summer camps, campgrounds, seasonal cottages and cabins, state forests and parks, fish hatcheries and game farms, ski areas and marinas.

(Note: Figures for golf courses are listed under agricultural self-supplied use).

Step 3. Determine Population Served

DEQE jurisdiction covers only those water supply systems serving a minimum of twenty-five people. This threshold figure is listed frequently on the DEQE printout and is used in this report unless other information on the size of the establishment was obtained or could be inferred from other material. Service population figures have not been independently checked with the respective listing. The meaning of the numbers is uncertain. For example, in the case of a restaurant, the numbers may refer to the number of workers employed, the seating capacity, the number of customers on an average day, or the number on the peak day of the season and can be regarded as the minimum service population for these commercial and institutional facilities.

Step 4. Determining Average Daily Water Use

Information on the 1980 average daily water use for commercial and institutional establishments in the Blackstone Study Area is not available. The water use figures listed in this report are not the actual usage of these facilities, but rather, are preliminary estimates. To obtain these estimates of water use, a surrogate method was developed by ascertaining actual daily demand for typical institutional and commercial establishments. Using a detailed analysis prepared by the City of Marlborough in 1982 of their large metered accounts (using more than 1,000 gallons a day) and other data available in the DWR files, a table was prepared of typical commercial and institutional facilities and "Rule of Thumb" figures were derived for each type of facility.

Step 5. Applying the "Rule of Thumb" estimates to the Blackstone Study Area

With the self-supplied establishments in the Blackstone Study Area identified and categorized, approximations of their water use were made by determining the relative size of the establishments and applying the appropriate "rule of thumb" water use estimates. For example, the New England Steakhouse in Mendon, a mid-sized restaurant with a service population of one hundred, would use about 4,000 gallons per day or .004 mgd. This process of estimation was carried out for each facility in the community and a total for the study area was generated by summing the community figures.

---

Note: See Attachments 5 and 6.

## TABLE B

### Blackstone Study Area
### Self-supplied Commercial / Institutional Water Use (1980)
### (Preliminary Estimates)

| Community | Estimated(1) Water Use (mgd) |
|---|---|
| Auburn | 0.002 |
| Bellingham | INA |
| Blackstone | INA |
| Boylston | INA |
| Douglas | 0.022 |
| Grafton | 0.006 |
| Hopedale | 0.005 |
| Leicester | INA |
| Mendon | 0.071 |
| Millbury | 0.005 |
| Millville | 0.013 |
| Northbridge | INA |
| North Attleboro | INA |
| Shrewsbury | 0.005 |
| Sutton | 0.070 |
| Upton | 0.005 |
| Uxbridge | 0.028 |
| Worcester | INA |
| Total: | 0.232 mgd |

(1) INA - Information Not Available

Note: For a complete understanding of the meaning or significance of these figures it is necessary to read and follow the methodology described in Appendix 4B.

Source: Division of Water Supply (DEQE) Model State Information System - Public Water System Inventory Subsystem, Comprehensive Report (1981 Printout).

ATTACHMENT 6

## Blackstone Basin
## Self-supplied Commercial/Institutional Water Users
## (Preliminary Estimates)

Categories

| Live-In Institutional | Day Use Educational | Business | Seasonal Recreational |
|---|---|---|---|
| Correctional Institutions, Hospitals, Nursing Homes, Seminaries, Colleges and Boarding Schools | Public and Private Day Schools, Museums Libraries, Churches and Town Offices | Hotels, Motels, Inns, Restaurants, Clubs, Misc. Business | Camps, Cabins, Camping grounds, State Forests, Parks, Ski Areas, Golf (non-irrigation use) |

| No. | Pop. Served | No. | Pop. Served | No. | Pop. Served | No. | Pop. Served |
|---|---|---|---|---|---|---|---|
| 3 | 102 | 8 | 2,708 | 24 | 2,235 | 6 | 450 |

| Est. Water Used | Est. Water Used | Est. Water Used | Est. Water Used |
|---|---|---|---|
| .012 mgd | .070 mgd | .118 mgd | .032 mgd |

| | | | |
|---|---|---|---|
| Basin Total | No. of self-supplied sources - 42 | Estimated | 1980 Water Use |
| | | ground | 0.232 mgd |
| | | surface | 0.0 mgd |

# APPENDIX 4C

## Self-supplied Industrial Water Use
## Blackstone River Basin

Purpose:

To estimate the amount of industrial self-supplied water use from sources within the hydrologic boundaries of the Blackstone River Basin in 1980.

a) Industrial self-supplied water use is an estimate in million gallons per day of water obtained by industry from self-supplied sources in 1980 for sanitary, cooling and/or processing purposes.

b) This amount does not include water supplied to industries from public water supply systems.

c) Some industries obtain water from both public water supply sources and self-supplied sources. This report pertains only to the water obtained from self-supplied sources.

Methodology:

Step 1. Generate a List of Industries Within the Blackstone Study Area

The Blackstone Study Area consists of all communities that lie fully or partially within the hydrologic boundaries of the Blackstone Basin. (See attachment 1 for map of study area)

The following sources were utilized to determine the industries located in the Blackstone Study Area.

Primary Source

a) New England Manufacturing Directory, 1983-84 edition

This directory gives a comprehensive listing of industry by community and lists basic data including street location, telephone number, number of employees, SIC code and contact person.

Secondary Sources

b) Division of Water Pollution Control (DEQE) Permits

A computer printout containing a list of permits for industrial surface and groundwater discharge gives the name of industry, community location, SIC code,* and the receiving river where water is discharged.

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*Standard Industrial Code

c) Central Massachusetts Regional Planning Commission Reports

1. Blackstone Valley Industrially Zoned-Land Survey and Analysis, 1982.

2. Industrial Sources Inventory "208" Wastewater Management Program, 1976.

d) Superintendents of Local Water Supply Agencies

Product

From the primary and secondary sources, a list was prepared of the industries located within the Blackstone Study Area. This list consists of 894 industries.

Step 2. List of Industries Within The Blackstone River Basin

The list of industries within the Blackstone Study Area was refined to include only those industries physically located within the Blackstone Basin hydrological boundaries. The basic assumption is that industries with self-supplied sources would have these sources on or in close proximity to their site location. Thus, if an industry is located within the basin, its source(s) of self-supplied water would be located, in most cases,within the Blackstone.

Of the 29 communities surveyed, 25 have a portion of their land area within the Blackstone and a portion in an adjoining basin. For these communities located partially in the Blackstone, each industry was plotted on street maps overlayed with the basin map. Industries that were found to be outside of the basin hydrological boundary were dropped from further analysis.

If an industry's basin location was in doubt, calls were made either to the industry contact person or the community water supply agency superintendent for clarification.

Product

A list was prepared of the 569 industries which are physically located within the Blackstone River Basin.

Step 3. Determine Which Basin Industries are Self-Supplied

This step consisted of two processes to determine self-supplied industries within the Blackstone River Basin.

a) Contact With Water Superintendents To Determine If Industries Are Publicly Supplied and/or Self-Supplied

Telephone contact was made with the superintendents of the local water supply agencies in the Blackstone River Basin towns to determine the source of supply of the industries located within their service area from the list of industries generated in Step 2.

If the water superintendent said that the public water system fully supplied an industry and was reasonably certain that the industry had no self-supplied sources, that industry was dropped from further consideration.

If the water superintendent was unaware of the industry or was uncertain of the industry's source of supply, the industry was contacted to ascertain if they had self-supplied sources.

This discussion with the water superintendents was used also to confirm the list of industries within each community (Step 1).

### Product

A list of 75 industries was generated based on the water superintendents' opinions of the fully or partially self-supplied industries with sources in the Blackstone River Basin.

### b) Contact Industries to Determine If They Definitely Have Self-supplied Sources

Telephone contact was made with the 75 industries to determine if they definitely had self-supplied sources. This further refined the list of self-supplied industries obtained from the water superintendents. In some cases, industries had stopped utilizing their self-supplied sources and were fully supplied by public supply sources or were located outside the Blackstone River Basin.

### Product

A final list was generated of 33 industries that have self-supplied source(s) in the Blackstone River Basin.

### Step 4. Estimate Average Day Demand and Water Use of Self-Supplied Sources

The following information was obtained by telephone for the 33 self-supplied industries.

#### a) Water Use

1) Processing, 2) Cooling, 3) Sanitary (employee)

#### b) Estimate of Average Daily Water Use

Most industries do not have meters. Thus, the average water use was estimated by the contact person using a variety of methods; e.g., percentage of pumping capacity of their wells, daily demand records on file, etc.

#### c) Type of Source

Groundwater or surface water

### d. Number of Employees

When industries responded that their self-supplied source was utilized only for sanitary purposes, the only question posed to them was the number of employees.

The standard of 20 gallons per employee per day multiplied by the number of employees is used to determine average day water use for industries that used their self-supplied source(s) only for sanitary purposes. This standard is taken from the MDC-Water Supply Study & EIS: Task 1-Water Demand Projections Report.

### Step 5. Findings

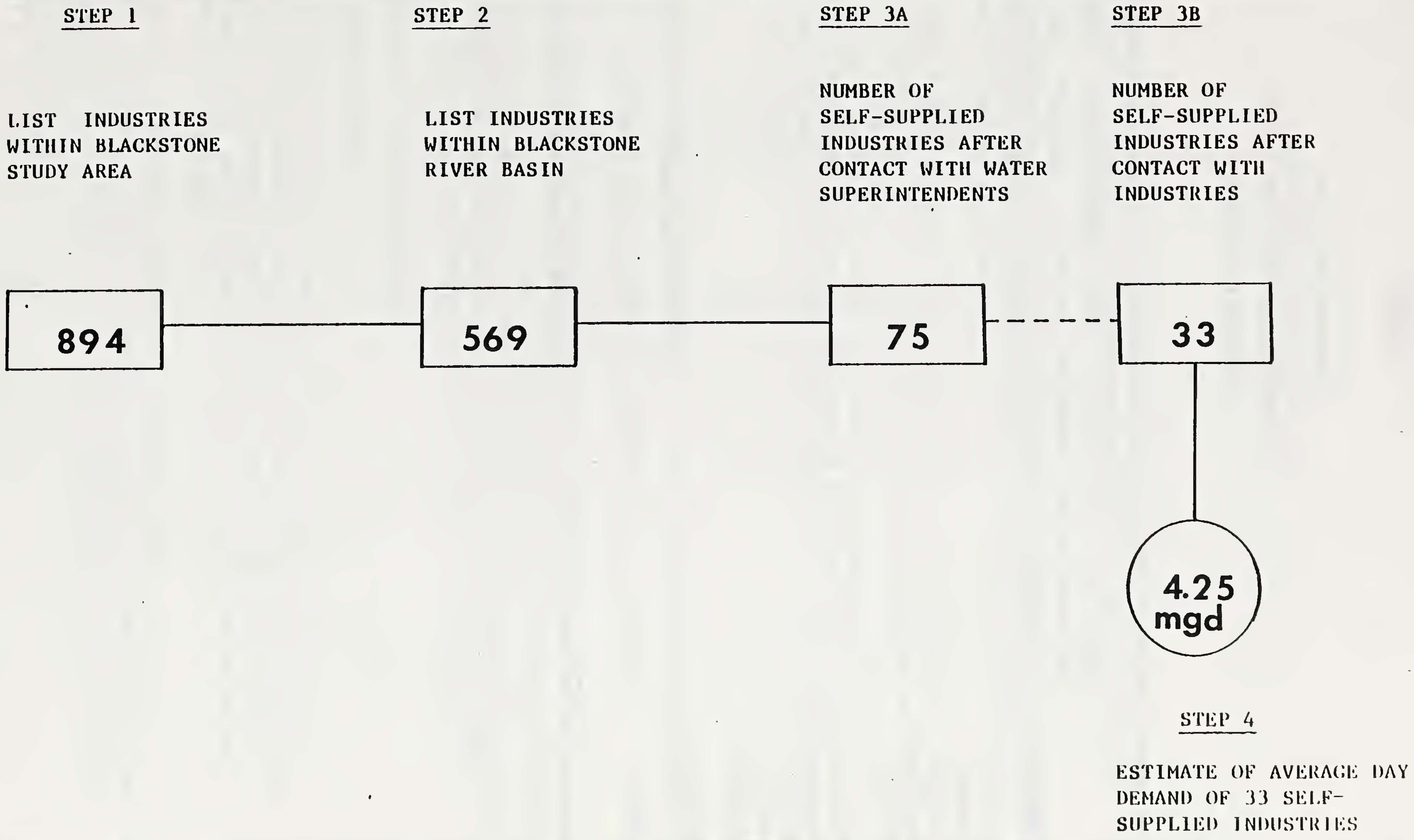
Attachment 7 is a flow chart illustrating Steps 1-4 used to estimate self-supplied industrial water use in the Blackstone Basin. Also included in the flow chart is the number of industries examined in each step.

Attachment 8 is a summary table arranged and aggregated by community showing the number of industrial self-supplied water users with sources within the hydrological boundaries of the Blackstone Basin, the summary of their 1980 average day demands, and the number of groundwater and surface water sources in each community.

## ATTACHMENT 7

### FLOW CHART

### METHODOLOGICAL APPROACH TO DETERMINE SELF-SUPPLIED INDUSTRIES IN BLACKSTONE BASIN


STEP 1
LIST INDUSTRIES WITHIN BLACKSTONE STUDY AREA
STEP 2
LIST INDUSTRIES WITHIN BLACKSTONE RIVER BASIN
STEP 3A
NUMBER OF SELF-SUPPLIED INDUSTRIES AFTER CONTACT WITH WATER SUPERINTENDENTS
STEP 3B
NUMBER OF SELF-SUPPLIED INDUSTRIES AFTER CONTACT WITH INDUSTRIES
894
569
75
33
4.25 mgd
STEP 4
ESTIMATE OF AVERAGE DAY DEMAND OF 33 SELF-SUPPLIED INDUSTRIES

## TABLE C

### Blackstone Study Area

### Self-supplied Industrial Water Use (1980)

### (Preliminary Estimates)

| Community | Number of Self-supplied Industries | 1980 Average Day Demand Self-supplied Industries | Number of Industries Groundwater Sources | Average* Day Demand | Number of Industries Surfacewater Sources | Average* Day Demand |
|---|---|---|---|---|---|---|
| Attleboro | 1 | .10 | 1 | (.10) | 0 | |
| Auburn | 3 | .15 | 3 | (.15) | 0 | |
| Grafton | 4 | .45 | 4 | (.45) | 0 | |
| Leicester | 1 | .07 | 0 | | 1 | (.07) |
| Mendon | 3 | .03 | 2 | (.01) | 1 | (.02) |
| Millbury | 4 | 2.01 | 3 | (2.01) | 1 | less than (.01) |
| Northbridge | 4 | .58 | 3 | (.55) | 1 | (.03) |
| Sutton | 6 | .37 | 5 | (.01) | 1 | (.36) |
| Uxbridge | 2 | .20 | 2 | (.20) | 0 | |
| Wrentham | 1 | .14 | 0 | | 1 | (.14) |
| Worcester | 4 | .15 | 4 | (.15) | 0 | |
| Total: | 33 | 4.25 mgd | 27 | (3.63) mg | 6 | (0.62) mgd |

*Average Day Demand obtained from these sources.

Note: For a complete understanding of the meaning or significance of these figures it is necessary to read and follow the methodology described in Appendix 4C.

## APPENDIX 4D

### Self-supplied Agricultural Water Use
### Blackstone River Basin

Purpose:

To estimate the amount of agricultural self-supplied water use from sources within the hydrologic boundaries of the Blackstone River Basin in 1980.

1. Agricultural self-supplied water use is an estimate, in million gallons per day, of water obtained by sources in 1980 for livestock and poultry and irrigation purposes.

2. This amount does not include water supplied to agriculture from public water supply systems nor self-supplied domestic on-farm water use.

3. As each farm unit has its own water use characteristics, an actual survey would be required to determine a precise figure. The following methodology was developed using existing data to estimate agricultural water use.

Methodology:

Agricultural Water Use Categories

The primary categories of agricultural water use are:

Livestock and poultry water use is drinking water and water used for sanitary purposes in the dairy operations.

Irrigation water use is water withdrawn from streams, ponds and wells, conveyed and applied to agricultural land and crops to increase yield.

Livestock and Poultry Water Use

1. Basic Formula

The basic formula to estimate livestock and poultry water use is to multiply the animal population for towns with "a significant level of agriculture" converted to animal units times the estimated annual water use per animal unit. This total divided by 365 gives an estimate of the average daily water use.

U.S. Soil Conservation Service research shows that water use per animal unit changes little during the course of the year; thus, town livestock water use divided by 365 gives a good estimate of the average daily water use.

---

Note: See attachments 9, 10, and 11.

2. Primary Sources of Data

a) Livestock and Poultry Population

The U.S. Soil Conservation Service, while researching The Agricultural Water Quality Study, obtained from the Massachusetts Department of Food and Agriculture 1980 livestock populations for towns with an agricultural industry.

b) Animal Units

The U.S. Soil Conservation Service has developed factors to convert livestock and poultry populations into animal units as a convenient measure to estimate feeding quantities, manure production and water use. Conversion factors for different types of livestock and poultry are shown in the table in attachment 12.

c) Water Use Per Animal Unit

The Soil Conservation Service has determined from field research the average annual water use per animal unit to be:

| Type of Animal | Annual Water Use Per Animal Unit (gallons) |
|---|---|
| Beef | 3600 |
| Dairy | 8000 |
| Poultry | 5500 |
| Other (horses, hogs, etc.) | 3800 |

d) Towns With Significant Agricultural Production

In completing the Massachusetts Agricultural Water Quality Study, the U.S. Soil Conservation Service identified 177 Massachusetts towns with a significant agricultural industry based on the criteria of having over 1000 acres of agricultural land or four or more dairy herds.

The other 174 towns had little or no agricultural production; thus, livestock and poultry water use in these towns would not be significant. Seven towns in the Blackstone Basin (Douglas, Grafton, Mendon, Northbridge, Shrewsbury, Sutton, and Uxbridge) have significant agricultural production.

## Irrigation Water Use

1. Irrigated Cropland

a) Basic formula

The basic formula to estimate existing irrigation water use is to multiply the amount of town cropland acreage irrigated by the annual water application rate.

b) Primary Source of Information

(1) Town Cropland Acreages

Town cropland acreages for the 177 towns with significant agriculture are listed in table A3-3 of the Agricultural Water Quality Study. This data was updated in 1980 by the U.S. Soil Conservation Service.

(2) Percentage of Cropland Irrigated Factor

There is no data available showing the percentage of town cropland which is irrigated. As a surrogate method, a percentage of cropland irrigated in each county was derived from data in the 1978 Census of Agriculture. This report listed for each county the total acreage of cropland and the acreage of irrigated cropland. From these figures a percentage of county cropland irrigated was derived to obtain a "percentage of county cropland irrigated factor".

This factor for Worcester County would be as follows:

| | |
|---|---|
| Total cropland in Worcester County | 59,387 acres |
| Total irrigated cropland in Worcester County | 612 acres |
| Percent of cropland irrigated | 1 percent |

By multiplying the 1 percent factor by the cropland acreage of the towns with significant agricultural acreage provides an estimate of the cropland acreage irrigated in the river basin. The factor would not be accurate for any single town, but in the aggregate of the river basin should provide a reasonable estimate.

(3) Annual Application Rate of Irrigation Water

An estimated annual application rate of water necessary to irrigate croplands, other than cranberry bogs, was derived from an analysis of irrigation requirements of various crops found in The Conservation Irrigation Guide for Massachusetts prepared by the U.S. Soil Conservation Service. In zones A and B an estimated eight (8) inches of water are applied annually, whereas in zone C six (6) inches of water are applied. (see map, Attachment 13.

The annual application rate of irrigation water for towns in the Blackstone Basin is eight (8) inches.

2. Golf Course Irrigation

a) Basic Formula

The basic formula to estimate golf course irrigation is to multiply an average golf-course acreage irrigated by the appropriate annual irrigation water application rates.

b) Sources of data

(1) Golf Course Acreage Irrigated

Based on information obtained from the golf industry, an 18 hole golf course contains, on the average, the following number of acres: greens (2.3 acres), tees (1.9 acres) and fairways (40 acres). It is estimated that one-half of the fairway acreage is irrigated along with the greens and tees acreage; thus, an 18 hole golf course would have about 24 acres of irrigated land and a nine hole golf course 12 acres.

(2) Annual Application Rate of Irrigation Water

The watering practices of individual golf courses are extremely variable and depend on the program developed by the course superintendents; plus, climate, soil, turf species and other factors. However, based on information provided by the golf industry, the Soil Conservation Service and the U.S. Cooperative Extension Service, the following annual applications of irrigation water was developed for the three different irrigation zones shown on map (Attachment 13); Zone A-8 inches/acre, Zone B-6 inches/acre, Zone C-4 inches/acre.

## TABLE D

### Blackstone Study Area
### 1980 Self-supplied Agricultural Water Use

| Community (1) | Water Use mgd (2) | Percent Livestock | Percent Irrigation |
|---|---|---|---|
| Auburn | .005 | -- | 100 |
| Blackstone | -- | -- | -- |
| Douglas | .004 | 84 | 16 |
| Grafton | .021 | 67 | 33 |
| Hopedale | .004 | -- | 100 |
| Mendon | .010 | 81 | 19 |
| Millbury | .005 | -- | 100 |
| Millville | -- | -- | -- |
| Northbridge | .028 | 57 | 43 |
| Shrewsbury | .004 | 92 | 8 |
| Sutton | .021 | 74 | 26 |
| Upton | .005 | -- | 100 |
| Uxbridge | .024 | 78 | 22 |
| Worcester | .011 | -- | 100 |
| Total: | .14 (mgd) (2) | | |

(1) Municipalities with significant agricultural or golf course irrigation.

(2) Millions of gallons per day is an average figure for the entire year which disregards seasonal variations. The Soil Conservation Service estimates that approximately half of the self-supplied agricultural water use comes from surface sources and half from groundwater sources.

ATTACHMENT 10

## BLACKSTONE RIVER BASIN

### Total Estimated Agricultural Water Use In 1980

| | IRRIGATION WATER USE | | | | LIVESTOCK WATER USE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Town/City | Cranberry Crop | Other Crops | Golf Courses | TOTAL Irrigation | (AU*) Dairy | (AU) Beef | (AU) Other | (AU) Poultry | TOTAL Livestock Water | TOTAL Agricultural Water | PERCENT Livestock Water | PERCENT Irrigation Water |
| Auburn | | | 1.97 | 1.97 | | | | | | 1.971 | | 100 |
| Douglas | N | 0.23 | | 0.23 | (135)<br>1.080 | (42)<br>0.151 | | N | (177)<br>1.231 | 1.465 | 84 | 16 |
| Grafton | O | 2.55 | | 2.55 | (560)<br>4.480 | (44)<br>0.158 | (149)<br>0.566 | O | (753)<br>5.204 | 7.758 | 67 | 33 |
| Hopedale | N | | 1.31 | 1.31 | | | | N | | 1.313 | | 100 |
| Mendon | E | 0.69 | | 0.69 | (206)<br>1.648 | (73)<br>0.623 | (165)<br>0.627 | E | (544)<br>2.898 | 3.590 | 81 | 19 |
| Millbury | | | 1.97 | 1.97 | | | | | | 1.971 | | 100 |
| Northbridge | | 0.46 | 3.94 | 4.41 | (651)<br>5.208 | (38)<br>0.137 | (110)<br>0.418 | | (799)<br>5.763 | 10.170 | 57 | 43 |
| Shrewsbury | | 0.13 | | 0.13 | (81)<br>0.648 | (35)<br>0.126 | (116)<br>0.441 | | (232)<br>1.215 | 1.345 | 90 | 10 |
| Sutton | | 2.02 | | 2.02 | (498)<br>3.984 | (265)<br>0.954 | (223)<br>0.847 | | (986)<br>5.785 | 7.802 | 74 | 26 |
| Upton | | | 1.97 | 1.97 | | | | | | 1.971 | | 100 |
| Uxbridge | | 1.00 | | 1.00 | (805)<br>6.400 | (62)<br>0.223 | (65)<br>0.247 | | (932)<br>6.910 | 8.906 | 78 | 22 |
| Worcester | | | 3.94 | 3.94 | | | | | | 3.942 | | 100 |
| TOTAL:<br>(millions of gallons per year) | | 8.08 | 15.10 | 23.19 | 23.49 | 2.37 | 3.15 | | 29.01 | 52.21 | | |

* The animal unit (AU) provides a measure to estimate annual livestock water use.

52.21 millions of gallons per year is the equivalent of an annual average of .14 millions of gallons per day.

ATTACHMENT 11

## TOWN of NORTHBRIDGE

### Self-supplied Agricultural Water Use in 1980

### I. Livestock and Poultry Water Use Estimate

Formula: Animal population converted to animal units multiplied by the estimated annual water use per animal unit equals annual livestock and poultry water use.

| Animal Type | Animal Population | Animal Units | Annual Water Use | Total Water Use (gallons) |
|---|---|---|---|---|
| Dairy | 559 | 651 | 8000 | 5,208,000 |
| Beef | 38 | 38 | 3600 | 136,800 |
| Other | 323 | 110 | 3800 | 418,000 |
| Poultry | -0- | N/A | -- | -- |
| | 920 | 799 | | *5,762,800 gallons or 17.7 acre feet |

### II. Irrigation Water Use

#### A. Irrigated Cropland

Formula: The town cropland acreage multiplied by the county percent cropland irrigated factor times the annual water application rate equals estimated irrigation water use.

1. Total cropland acreage in Northbridge: 214 acres
2. Annual water application rate for Blackstone Basin towns is .66 acre feet per year.

214 acres x .01 = 2.14 acres x .66 acre feet = 1.41 acre feet (or 459,419 gallons per year).

#### B. Golf Course Irrigation Water Use

Basic formula: Average area irrigated times annual golf course irrigation water application rate equals annual golf course water use.

1. Juniper Hill Golf Course (18 holes):
   24.2 acres of irrigated greens, tees and fairways.
2. Annual golf course irrigation water application rate for Blackstone Basin towns is .50 acre feet per year.
   24.2 acres x .50 acre feet = 12.1 acre feet or 3,942,530 gallons per year.

## III. Town Summary - 1980 Agricultural Self-Supplied Water Use

| | Acre Feet | Gallons |
|---|---|---|
| Livestock | 18 | 5,762,800 |
| Irrigation | 14 | 4,401,949 |
| | 32 | 10,164,749 |

Average withdrawal in millions of gallons per day = 10,164,749 ÷ 365 = .028 mgd.

* One acre foot is equal to 325,829 gallons

## MASSACHUSETTS AGRICULTURAL WATER QUALITY STUDY

### TABLE A3-2 - Animal Units [1/]

| Animal | Weight Range lbs. | Average Weight | Animal Units per Animal | Number of Animals per AU |
|---|---|---|---|---|
| Dairy Cattle | | | | |
| Cows (2 yrs. & older) | 800-1400 | 1400 | 1.4 | 0.7 |
| Heifers (1 to 2 yrs.) | 500-1200 | 700 | 0.7 | 1.4 |
| Calves | 75-700 | 400 | 0.4 | 2.5 |
| Bulls | 900-1500 | 1400 | 1.4 | 0.7 |
| Beef Cattle<br>1 yr. ave. wt. 600 lbs.<br>2 yrs. ave. wt. 1100 lbs. | | 1000 | 1.0 | 1.0 |
| Oxen | 1200+ | 1400 | 1.4 | 0.7 |
| Horses (2 yrs. & older) | 400-1300 | 1000 | 1.0 | 1.0 |
| Ponies, Donkeys | 400-800 | 600 | 0.6 | 1.7 |
| Sheep | 100-180 | 140 | 0.14 | 7. |
| Goats | 50-150 | 125 | 0.125 | 8. |
| Pigs | 40-400+ | 280 | 0.28 | 3.5 |
| Ducks | 4-7 | 5 | 0.005 | 200 |
| Chickens | 4-5 | 4 | 0.004 | 250 |
| Turkeys | 5-25 | 10 | 0.01 | 100 |

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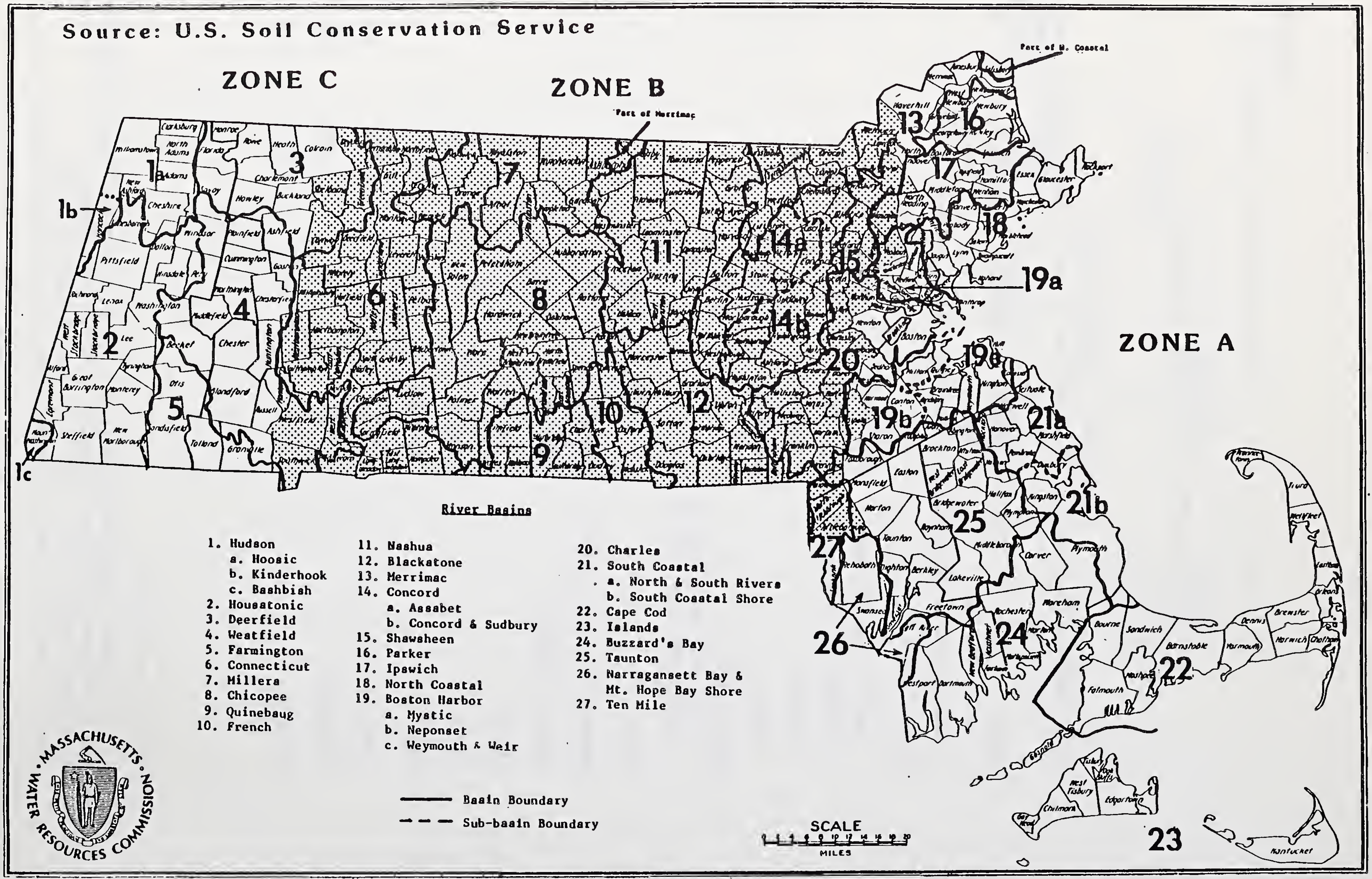
[1/] Values from SCS Agricultural Waste Management Manual, Loading Functions for Assessment of Water Pollution from Nonpoint Sources EPA (600/2-76-151) and from field experience of SCS personnel in Massachusetts.

Source: Page A3-4 Massachusetts Agricultural Water Quality Study, August 1984

# IRRIGATION ZONE MAP

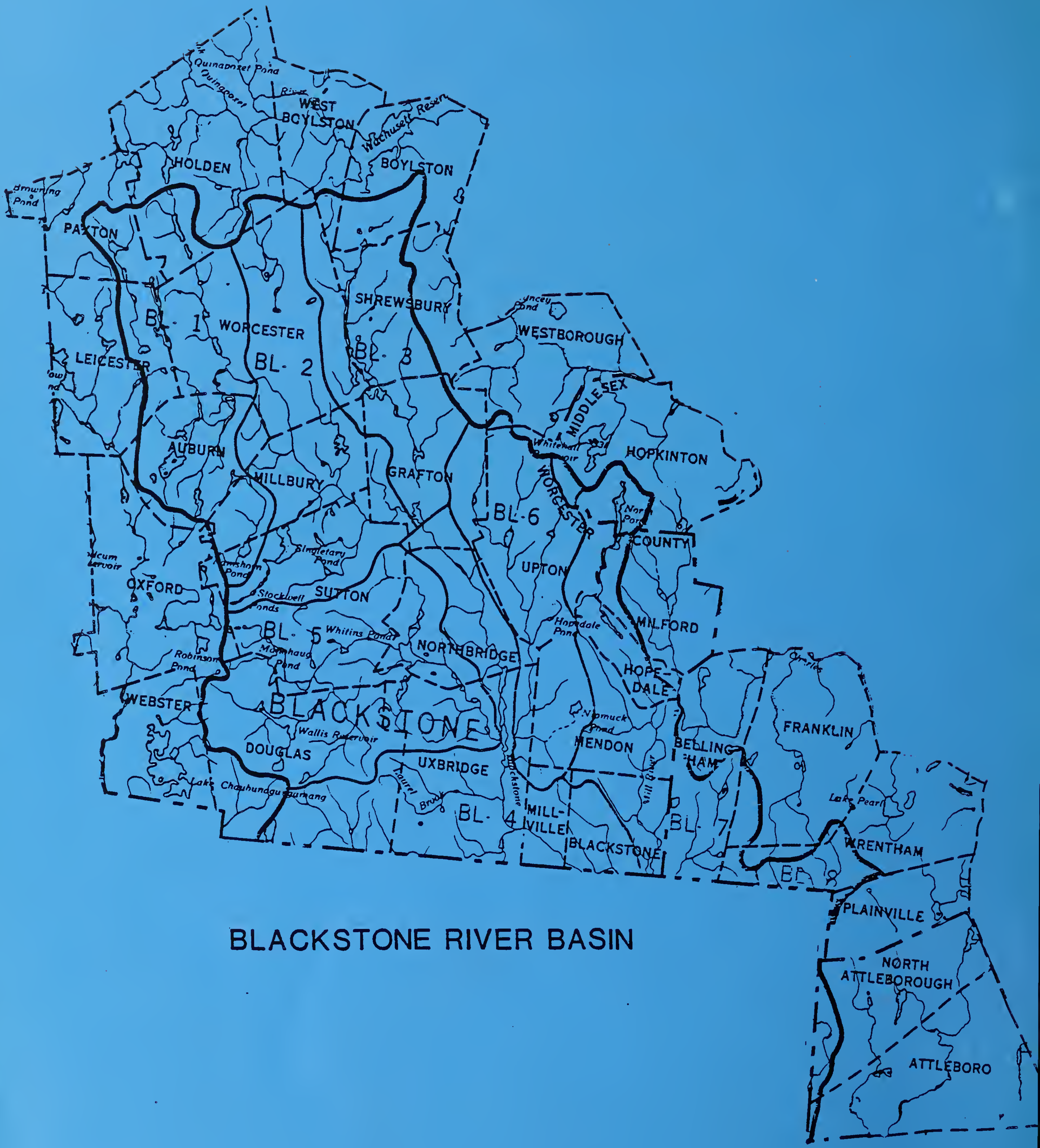


River Basins

1. Hudson
   a. Hoosic
   b. Kinderhook
   c. Bashbish
2. Housatonic
3. Deerfield
4. Westfield
5. Farmington
6. Connecticut
7. Millers
8. Chicopee
9. Quinebaug
10. French
11. Nashua
12. Blackstone
13. Merrimac
14. Concord
    a. Assabet
    b. Concord & Sudbury
15. Shawsheen
16. Parker
17. Ipswich
18. North Coastal
19. Boston Harbor
    a. Mystic
    b. Neponset
    c. Weymouth & Weir
20. Charles
21. South Coastal
    a. North & South Rivers
    b. South Coastal Shore
22. Cape Cod
23. Islands
24. Buzzard's Bay
25. Taunton
26. Narragansett Bay & Mt. Hope Bay Shore
27. Ten Mile

**Executive Office of Environmental Affairs - Water Resources Commission**

Draft Map Prepared by Division of Water Resources (D.E.M.)



BLACKSTONE RIVER BASIN